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FEASIBILITY COST AND CONCEPTUAL DESIGN STUDY OF AUTOMATED COAL CAR COVER SYSTEMS FOR ABATEMENT OF FUGITIVE COAL DUST FROM UNIT TRAINS

Prepared for Environment Canada by
The Cambrian Engineering Group Limited
Calgary, Alberta

May 1982

FEASIBILITY COST AND CONCEPTUAL DESIGN STUDY OF AUTOMATED COAL CAR COVER SYSTEMS FOR ABATEMENT OF FUGITIVE COAL DUST FROM UNIT TRAINS *

Fuel Processes Division
Engineering Assessment Branch
Air Pollution Control Directorate
Environment Canada
Ottawa, K1A 1C8

May, 1982

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FINAL REPORT

FOR

AIR POLLUTION CONTROL DIRECTORATE
ENVIRONMENT CANADA

Feasibility, Cost and Conceptual Design Study of Automated Coal Car Cover Systems Designed for Abatement of Fugitive Coal Dust.

DSS File No. 40SS.KE145-1-0458.

March 10, 1982

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1.0 INTRODUCTION

PHASE ONE - REPORT

Background

The purpose of this report is to present the technical and cost feasibility of equipping Canadian rail coal cars with an automated loading/unloading cover system designed to abate all fugitive coal emissions.

The report is being undertaken at the request of The Department of Supply and Services for Environment Canada. The final report will be submitted to the Scientific Authority on or before March 15, 1982.

The report is to be undertaken in three phases, the first comprises background and information research, the second comprises an evaluation of conceptual designs and a selection of the most promising alternative. Phase three will be the final report.

This report addresses the first phase of the work.

Information covered in this report was obtained by visits and discussions with key personnel at the terminal facilities, coal producing facilities, the railway companies, and manufacturers and users of existing rail car covers.

2.0 BACKGROUND

2.1 General

Coal is assuming an increasingly important role in Western Canada, which is fortunate to have abundant supplies, with reserves which will last hundreds of years at present rates of consumption.

This coal is used in Canadian and international markets for thermal and metallurgical uses.

The job of moving coal to consumers is enormous. Except for thermal coals consumed by nearby local electric power stations, most coal from Western Canada must be shipped long distances. The largest single problem common to all producers is the immense size of this country. Even with today's modern technology and equipment, transportation of bulk commodities, like coal, within Canada's boundaries is complex, costly, and time consuming. Most mines, particularly those within the mountainous areas of Alberta and British Columbia, are faced with the problem of moving coal to markets or tidewater hundreds or thousands of kilometres away, thus adding greatly to the cost of using and marketing domestically-produced coal.

Much of the coal produced by the major producing mines in Western Canada is transported to terminals in British Columbia and Thunder Bay by unit trains. These are generally made up of 98 to 108 coal cars and multiple diesel locomotives. The unit train system consists of a number of trains which remain intact while shuttling between the mine and the terminal. This is the most efficient method of rail transportation.

Substantial volumes of coal are being handled by the railways now. The present systems, equipment and facilities are operating at or near capacity at this time. Substantial upgrading will be required to handle the volumes predicted in the future.

Coal from the Western Canadian mines is received by ports on the West Coast and at Thunder Bay. At these terminals, coal is loaded directly from unit trains or stockpiles onto large bulk carrier ships for shipment to the customers. The existing ports on the West Coast are operating at capacity now and expansion programs and new facilities are under way.

2.2 Railways

Most of the coal is moved by the railways in Western Canada. These are:

BRITISH COLUMBIA RAILWAYS
CANADIAN NATIONAL RAILWAYS
CANADIAN PACIFIC RAILWAYS

2.3 Mines

The following major producing and future producing mines are or will be using the unit train system.

MANALTA COAL LTD.	-	KLIMAX MINE, Estevan, Saskatchewan
BIENFAIT COAL CO. LTD.	-	BIENFAIT MINE, Bienfait, Saskatchewan
FORESTBURG COLLIERIES LTD.	-	DIPLOMAT MINE, Forestburg, Alberta
McINTYRE MINES	-	Grande Cache, Alberta
LUSCAR STERCO (1977) LTD.	-	COAL VALLEY MINE, Edson, Alberta
CARDINAL RIVER COAL LTD.	-	LUSCAR MINE, Hinton, Alberta
MANALTA COAL LTD.	-	ROSELYN MINE, Sheerness, Alberta
FORDING COAL LTD.	-	Elkford, B.C.
B.C. COAL LTD.	-	HARMER SURFACE MINE, Sparwood, B.C.
B.C. COAL LTD.	-	MICHEL UNDERGROUND MINE, Sparwood, B.C.
B.C. COAL LTD.	-	GREEN HILLS MINE, Elkford, B.C.
BP CANADA LTD.	-	SUKUNKA, Chetwynd, B.C.
DENISON MINES LTD.	-	DENTHERM, Alberta
CROWSNEST RESOURCES	-	LINE CREEK, Sparwood, B.C.
DENISON MINES LTD. & ASSOC.	-	QUINTETTE MINE, Tumbler Ridge, B.C.
TECK CORPORATION	-	BULLMOOSE MINE, Tumbler Ridge, B.C.

2.4 Terminals and Ports

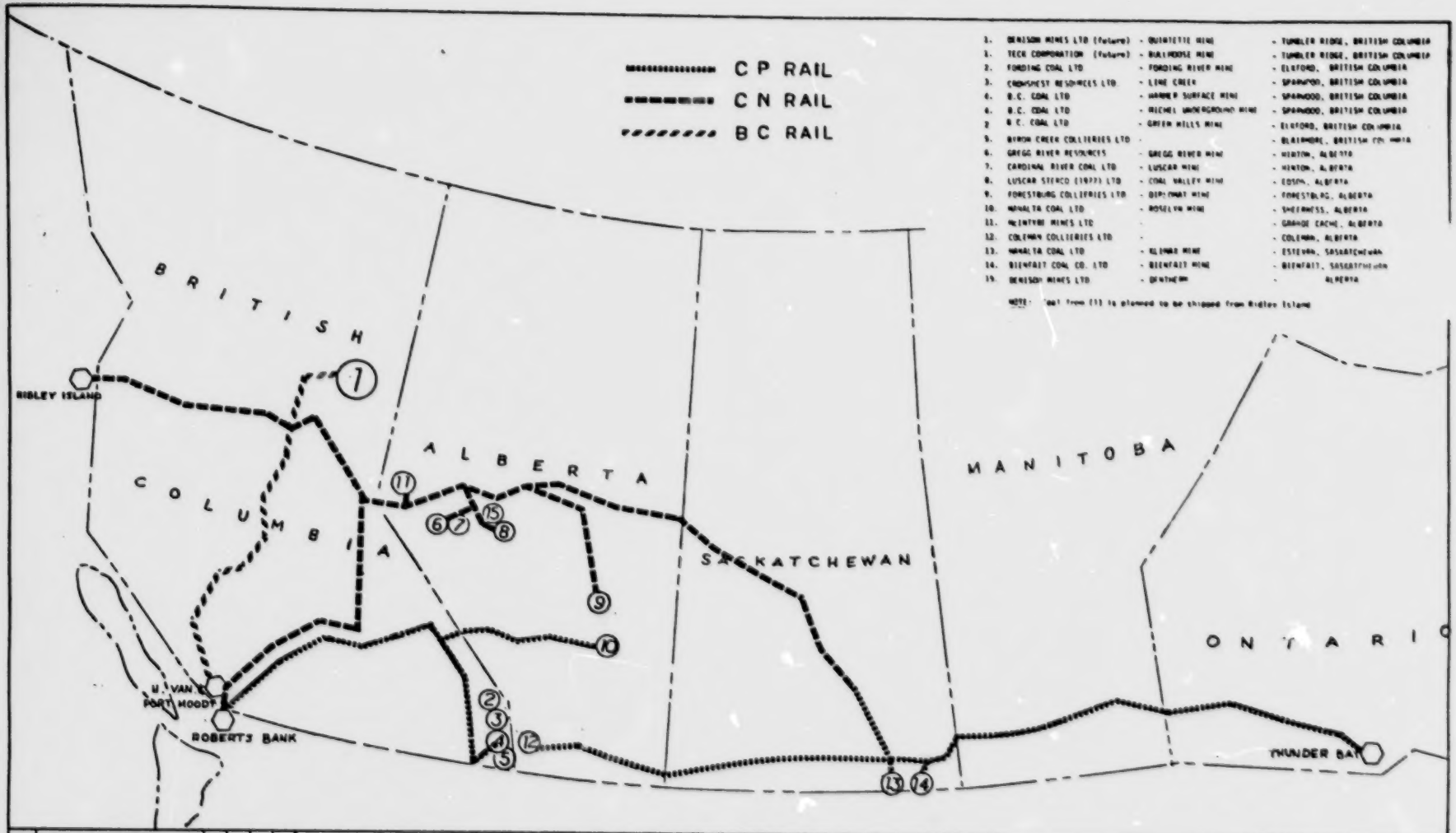
The railways haul coal from the producing mines to the following terminals located in British Columbia and Ontario.

NEPTUNE BULK TERMINALS	-	NORTH VANCOUVER, B.C.
PACIFIC BULK TERMINALS	-	PORT MOODY, B.C.
WESTSHORE TERMINALS LTD.	-	ROBERTS BANK, B.C.
THUNDER BAY TERMINALS LTD.	-	McKELLAR ISLAND, Ontario

A terminal is to be constructed at Ridley Island in northwest British Columbia for international coal shipments.

2.5 Coal Routes in Western Canada

SK001 shows major mine and terminal locations in Western Canada and the rail route systems serving them.


CP RAIL
CN RAIL
BC RAIL
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
RIDLEY ISLAND
U. VAN
PORT MOODY
ROBERTS BANK
THUNDER BAY
1. DENISON MINES LTD (future) - QUINTETTE MINE - TUMBLER RIDGE, BRITISH COLUMBIA
1. TECK CORPORATION (future) - KILLMOOSE MINE - TUMBLER RIDGE, BRITISH COLUMBIA
2. FORDING COAL LTD - FORDING RIVER MINE - ELKFORD, BRITISH COLUMBIA
3. CROWSNEST RESOURCES LTD - LINE CREEK - SPARWOOD, BRITISH COLUMBIA
4. B.C. COAL LTD - HARMER SURFACE MINE - SPARWOOD, BRITISH COLUMBIA
4. B.C. COAL LTD - MICHEL UNDERGROUND MINE - SPARWOOD, BRITISH COLUMBIA
5. B.C. COAL LTD - GREEN HILLS MINE - ELKFORD, BRITISH COLUMBIA
6. BYRON CREEK COLLIERIES LTD - - BLAIRMORE, BRITISH COLUMBIA
6. GREGG RIVER RESOURCES - GREGG RIVER MINE - HINTON, ALBERTA
7. CARDINAL RIVER COAL LTD - LUSCAR MINE - HINTON, ALBERTA
8. LUSCAR STELCO (1977) LTD - COAL VALLEY MINE - EDSON, ALBERTA
9. FORESTBURG COLLIERIES LTD - DIPLOMAT MINE - FORESTBURG, ALBERTA
10. MANALTA COAL LTD - ROSELYN MINE - SHERRESS, ALBERTA
11. McINTYRE MINES LTD - - GRANDE CACHE, ALBERTA
12. COLEMAN COLLIERIES LTD - - COLEMAN, ALBERTA
13. MANALTA COAL LTD - KLEINAR MINE - ESTEVAN, SASKATCHEWAN
14. BIENFAIT COAL CO. LTD - BIENFAIT MINE - BIENFAIT, SASKATCHEWAN
15. DENISON MINES LTD - DRUMHELLER - ALBERTA
NOTE: coal from (1) is planned to be shipped from Ridley Island

NO	REVISION	BY	DATE	CHK	APVD

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CLIENT APPROVAL: APPROVAL DATE, APPROVAL

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the cambrian group

PROJECT NUMBER B-1265

MAIN PRODUCING COAL MINES - RAILWAY & TERMINALS IN WESTERN CANADA

The Cambrian Engineering Group Limited

DESIGN

DRAWN D.MA CHECKED

SCALE NONE

DRAWING NUMBER SK-001 REV △

3.0 UNIT TRAINS

3.1 General

Much of the coal produced by the major producing mines in Western Canada is transported to terminals in British Columbia and Thunder Bay by unit trains. Unit trains are presently operated in continuous service by C.N. and C.P.

Unit trains generally vary from 98 cars for C.N. to 108 cars for C.P. of 91 to 95 metric tonnes each.

The unit trains are pulled by diesel locomotives. C.P. unit trains operating from southeastern British Columbia are equipped with slave locomotives and a robot car for remote control, set in the middle of the train. The slave locomotives are controlled from the lead locomotive.

3.2 Unit Train Cars

In general, there are over 3000 coal cars used in the unit train system in Western Canada at present. This number will increase to at least 4000 in the next 2 or 3 years.

The three major railways in Western Canada operate a mixed fleet of C.P.R. owned cars, C.N.R. owned cars, leased cars, and shipper owned cars. These cars have varying lengths, heights, widths, and load capacities, and the dimensions of individual cars will vary considerably.

Cars being added to the fleet in future may have different box dimensions and carrying capacities than those presently in use.

The cars used in the unit train system are solid bottom gondolas with rotary couplings to allow rotary dumping without uncoupling.

Railroad cars presently in use are as follows:

	CPR Bathtub	CPR Aluminum "Bathtub"	CNR Gondola Car
Length coupler to coupler	58'-7"	58'-7"	58'-7"
Truck spacing (bogie centres)	45'-0"	45'-0"	45'-0"
Axle spacing	5'-10"	5'-10"	5'-10"
Wheel diameter	36"	36"	36"
Box length, internal	48'-0"	±52'	52'-3"
Box length, external	varies slightly	varies slightly	varies slightly
Box width, internal	9'-11"	9'-11"	9'-9"
Box height from top of rail	varies 12'-3" to 13'-0"	varies 12'-3" to 13'-0"	varies 11'-10"
Light (tare) weight (approx.)	54,000 lb	varies 42,000 to 45,000 lb	varies 56,000 to 59,800 lb
Maximum gross weight	263,000 lb	263,000 lb	262,500 lb

3.3 Unit Train Fleets

At present Canadian National Rail operates fourteen train sets comprising approximately 1370 coal cars for unit train coal movement, and estimate approximately ten additional sets will be required for the movement from new mines in British Columbia to the terminals at Prince Rupert and Roberts Bank, making the total number of cars in unit train service in the order of 2350.

Canadian Pacific Rail's present unit train fleet consists of approximately 1600 cars, made up into 15 train sets. These are a mixture of several variations of bathtub cars, aluminum cars, and leased cars. C.P. Rail are considering aluminum cars for future increases to their fleet to obtain extra hauling capacity with fewer trains. Dimensionally, these aluminum cars may differ from existing C.P. aluminum cars.

British Columbia Rail are presently leasing approximately 100 coal cars of 100 tons capacity from U.N.P.X. in the United States. These cars are only used intermittently, as B.C. Rail do not have a continuous unit train operation to the terminal at Neptune. These trains are not unit trains, but consist of a group of forty to fifty coal cars combined into a train with cars carrying other materials.

B.C. Rail are planning to use unit trains from the fall of 1983 to haul coal from Tumbler Ridge to Prince George, a distance of approximately 140 miles. C.N.R. will then haul the coal the remaining 500 miles to Prince Rupert.

B.C. Rail have made no commitment to purchase any coal cars. They may use a pool system with C.N.R.

3.4 Scheduling and Operating Unit Trains

Most of the unit trains are owned or leased by the railways, but several train sets of cars are leased or owned by the shippers.

C.N. tries to dedicate each unit train to a particular shipper. Such trains generally always return to the same mine. If the mine has insufficient coal to load a train upon its scheduled arrival, the train may be made available for use by, and redirected to another shipper. Trains consisting of cars owned or leased by a shipper are not shared.

C.P. schedules its operation in a similar manner.

It can be seen that trains are scheduled and operated as a sort of loose pool by the railways to obtain maximum utilization of the equipment. Trains do not necessarily return to the same mine nor the same port on every trip. It can be concluded that special fixtures on certain trains would limit the present system flexibility and could require additional equipment and rail parking space.

Cars requiring maintenance are pulled out of train sets and replaced with spare cars. Thus, the cars rotate from one train to another.

C.P. also turns its cars end for end occasionally to even wear on wheels. C.P. has found that wear on the front wheels is different than on the rear, and different on the left side than on the right. Turning the car enables longer periods between maintenance.

4.0 LOADING STATIONS

4.1 General

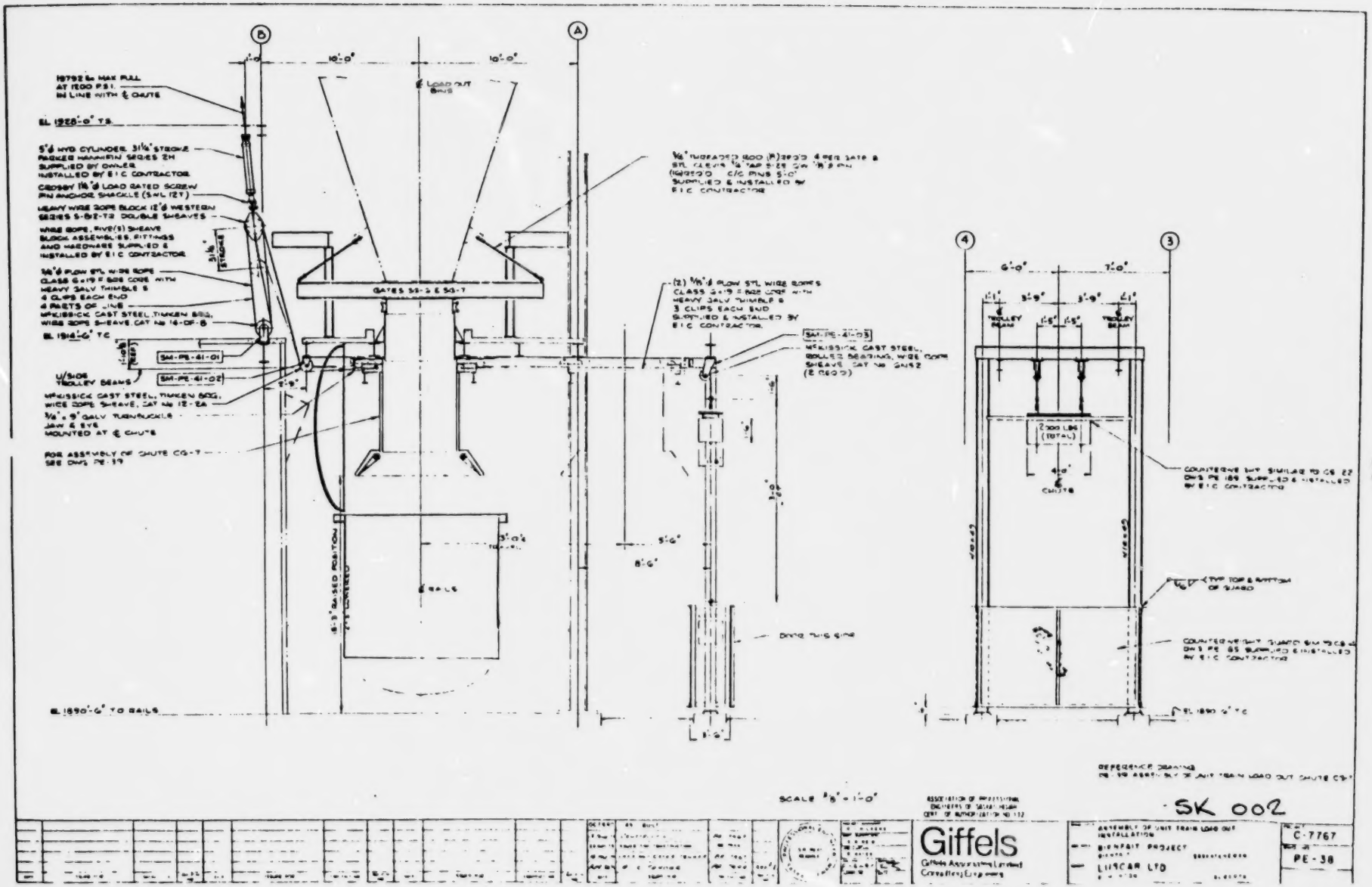
Each of the mines in Western Canada load coal into the unit trains through a high capacity loadout station.

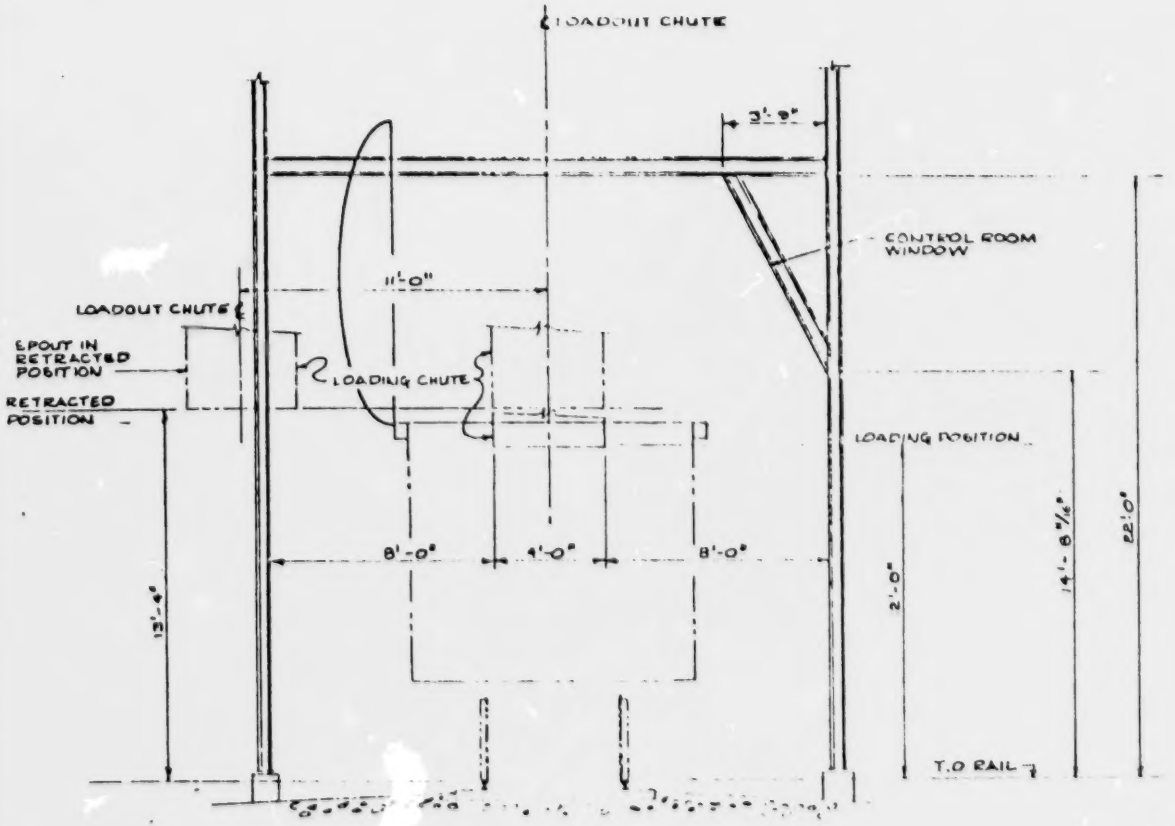
The typical loadout consists of a structure spanning the railway tracks and supporting a silo or bin containing the coal. As the train moves beneath the structure, coal is loaded into the coal cars through a chute. The train is in continuous motion during the loading process; it does not stop.

Some of the loadout facilities are partly automated to control the loading sequence and in some cases the weight of the coal being loaded into each car. Generally each loadout chute is monitored or controlled by one operator. Another operator or helper may be assigned to assist with other miscellaneous duties during the loading.

4.2 Dimensions of Loadout Facilities

The major shippers of coal were requested to supply dimensioned drawings, sketches, or photographs of their structures, from which we were able to assess the constraints of handling covers of the coal cars with respect to loadout stations. Sketches SK002 and SK003 showing typical loadout dimensions are included and clearly show interference between the type of cover that is hinged on one side and the loadout structure.


B
A
10'-0"
10'-0"
℄ LOAD OUT CHUTE
EL 1928'-0" T.S.
5'ø HYD CYLINDER 31¼" STROKE
PRALEX HAMMERIN SERIES 2H
SUPPLIED BY OWNER
INSTALLED BY E.I.C. CONTRACTOR
CROSBY 1½'ø LOAD RATED SCREW
PIN ANCHOR SHACKLE (S.W.L. 12T)
HEAVY WIRE ROPE BLOCK 12'ø WESTERN
SERIES S-82-T2 DOUBLE SHEAVES
WIRE ROPE, FIVE(5) SHEAVE
BLOCK ASSEMBLIES, FITTINGS
AND HARDWARE SUPPLIED &
INSTALLED BY E.I.C. CONTRACTOR
3/4" STROKE
¾'ø FLOW STL. WIRE ROPE
CLASS 6 x 19 F.C. ROPE CORE WITH
HEAVY GALV. THIMBLE &
4 CLIPS EACH END
4 PARTS OF LINE
MALLEABLE CAST STEEL TIMKEN BEG.
WIRE ROPE SHEAVE CAT. No. 14-DF-8
EL 1914'-6" T.C.
1'-0" DEEP
SM-PE-41-01
SM-PE-41-02
U/SIDE TROLLEY BEAMS
2'-9"
MALLEABLE CAST STEEL, TIMKEN BEG.
WIRE ROPE SHEAVE, CAT. No. 12-EA
⅝" x 9" GALV. TURNBUCKLE
JAW & EYE
MOUNTED AT ℄ CHUTE
FOR ASSEMBLY OF CHUTE CG-7
SEE DWG. PE-39
EL 1890'-6" TO RAILS
GATES S3-2 & S3-7
⅝" THREADED ROD (R) BENT 6 PER SIDE &
STL. PLATE ¼" THK. 5" DIA. WITH 3 PIN
HOLES C/C PINS 5'-0"
SUPPLIED & INSTALLED BY
E.I.C. CONTRACTOR
(2) ⅝'ø FLOW STL. WIRE ROPES
CLASS 6 x 19 F.C. ROPE CORE WITH
HEAVY GALV. THIMBLE &
3 CLIPS EACH END
SUPPLIED & INSTALLED BY
E.I.C. CONTRACTOR
SM-PE-41-03
MALLEABLE CAST STEEL,
ROLLER BEARINGS, WIRE ROPE
SHEAVE CAT. No. SH452
(2 REQ'D)
5'-0"
8'-0"
3'-0"
5'-0"
RAISED POSITION
LOWERED
RAILS
DRIVE THIS SIDE
4
3
6'-0"
7'-0"
TROLLEY BEAM
TROLLEY BEAM
2300 LBS (TOTAL)
4'-0" CHUTE
COUNTERWEIGHT SIMILAR TO CG-22
SM-PE-189 SUPPLIED & INSTALLED
BY E.I.C. CONTRACTOR
TYP. TOP & BOTTOM OF GUARD
COUNTERWEIGHT GUARD SIM. TO CG-4
SM-PE-85 SUPPLIED & INSTALLED
BY E.I.C. CONTRACTOR
EL 1890'-6" T.C.
REFERENCE DRAWING
SCALE ⅜"=1'-0"
SK 002
Giffels
Giffels Associates Limited
Consulting Engineers
ASSEMBLY OF UNIT TRAIN LOAD OUT INSTALLATION
BIRKPORT PROJECT
LUSCAR LTD
C-7767
PE-38



CLEAN COAL LOADOUT
SECTION AA
1/4" = 1'-0"

MINE - LUSCAR STERCO - COAL VALLEY
DATE - DEC 13. 1981
INFORMATION SUPPLIED BY - R. STRONG
(403) 794 - 3700

SK. 003

5.0 TERMINAL FACILITIES

5.1 General

The terminals on the west coast and Thunder Bay received approximately 20 million tonnes of metallurgical and thermal coal from western Canadian producers during 1980. This figure will increase as existing shippers increase volumes and new mines are opened. The estimated quantity of coal to be handled at the terminals in 1985 will be in excess of 31 million tonnes.

All the unit trains in Western Canada are emptied by rotary dumper. Bottom dump cars are not used (except for Cape Breton Development Corporation in Nova Scotia, which is not part of this study).

A train indexing-positioning system moves the entire train, as a unit, through the dumper, one car (two in a tandem dumper) at a time. When the car is properly positioned, the dumper turns it over. The car is clamped in position by two vertically moving clamps located approximately 10 feet from each end of the car. Pads are welded to the top sill of the car at the clamp points. The rotary couplings permit the car to roll over in order to dump the load.

5.2 Westshore Terminals, Roberts Bank, Vancouver

Westshore Terminals Ltd. handling facilities are located at Roberts Bank, Delta, near Vancouver, B.C.

Incoming unit trains are unloaded by a single-car Heyl and Patterson rotary dumper. The dumper is enclosed in a building. The complete unloading cycle time is approximately 120-130 seconds per car. As the cars leave the dump building, they are washed to remove excess coal dust, that has accumulated on the outside of the car. When the unloading is complete, the train returns to the mine.

Westshore Terminals are now in their first phase of expansion. A tandem Dravo-Wellman dumper is on order and will be operational in March, 1983. The tandem and single dumpers will operate concurrently. A second tandem dumper will be installed in 1985 at which time the existing Heyl and Patterson single-car dumper will be removed.

A further expansion to Roberts Bank is pending.

5.3 Neptune Terminals, Vancouver

Neptune Bulk Terminals Ltd. operate unloading facilities in North Vancouver on the Burrard Inlet.

Unit trains of up to 105 cars in length can be emptied. Neptune Bulk Terminals operate a Heyl and Patterson single rotary dumper which is entirely enclosed in a building with a dust extraction system.

5.4 Pacific Bulk Terminals, Vancouver

Pacific Bulk Terminals operate unloading facilities at Port Moody at the east end of the Burrard Inlet in British Columbia.

The Link Belt single rotary dumper is the original dumper on the west coast and is 21 years old, still operating very well. It is housed in a building.

When a train arrives at the terminal, each car is uncoupled and moved to the rotary dumper in units of 3 cars by a front end loader adapted with a coupler. The first car of the 3 car unit is positioned in the rotary dump, is clamped and rotated to empty. When it is uprighted the front end loader pushes the second car into the dumping position which pushes the first car out of the dump shed down a ramp. The car accelerates forward, then runs up a ramp which stops and reverses the car back down a side track.

At the present time approximately one train a week (±98 cars) is received from Coleman mines, and 60 cars per week carrying petroleum coke from Fort McMurray.

5.5 Vancouver Wharves, British Columbia

Vancouver Wharves facilities are located in North Vancouver on the Burrard Inlet.

Vancouver Wharves generally does not handle coal. Vancouver Wharves does not have a rotary dumper. Cars of bulk material such as copper concentrate are unloaded by a Gradall backhoe.

Some of the cars at Vancouver Wharves are equipped with removable fibreglass covers. A Heede 2½ ton gantry crane is used to lift off and replace these covers. Approximately 20-22 cars per day are handled in this manner.

A thaw shed is under construction.

5.6 Ridley Island, Prince Rupert

A new world scale coal terminal and port facility is being established at Ridley Island, near Prince Rupert in British Columbia.

The proposed coal handling facilities should be operational by 1983. It will include a new rotary car dumper facility for emptying unit trains.

5.7 Thunder Bay Terminals Ltd., Thunder Bay, Ontario

Thunder Bay Terminals Ltd. is located on McKellar Island in Thunder Bay, Ontario.

The terminal handles coal from Western Canadian mines destined for use in thermal generating stations operated by Ontario Hydro.

The unloading facilities at Thunder Bay include a Strachan and Henshaw rotary dumper and indexer which are both housed in a building which is fitted with a dust cowl and dust extraction equipment.

The terminal has thaw sheds for loosening coal frozen in the cars upon their arrival.

6.0 FUGITIVE COAL DUST EMISSIONS

6.1 Losses from Dusting

Previous studies on fugitive dust emissions from coal cars suggest that prior to the application of binders to the surface of the coal in the coal cars, losses could be 1.0 tonne per car of 100 tonnes capacity, over a distance of 700 miles.

In 1974 all major mining companies operating in Western Canada volunteered to supply reasonable measures to control the coal dust eminating from moving trains. They did this by spraying every coal train leaving their property with a binder that formed a crust on top of each car. This crust has a maximum estimated effectiveness of 85% in reducing dusting from the coal trains. Losses from dusting have thus been reduced by spraying to about 0.15 tonnes per car.

The financial losses of uncontrolled dusting are enormous. Based on a 1981 annual production of 20 million tonnes per year moved by 215,000 car trips, and on a 1981 value of $65.00 per tonne, the losses might be calculated as follows:

	assumed tons lost per car	assumed tons lost per year	assumed $ lost per year
Western Canadian production; 20 million tonnes:			
without spraying	1.0	215,000	$13,975,000
with spraying	0.15	32,250	$ 2,096,000
Typical mine production; 2.5 million tonnes:			
without spraying	1.0	26,875	$ 1,747,000
with spraying	0.15	4,030	$ 261,950

6.2 Dusting from Empty Cars

There are some indications of dusting from empty cars. Some of the coal not emptied out of the car may be blown out by air turbulence in the empty car. Also a layer of coal is left on top of the top sill or on external surfaces of each car after dumping, and if not washed off it remains on the car until the train gains speed and is then blown off. Sometimes this coal layer can be 3" or 4" thick.

The amount of dust created by empty cars has not been analyzed to date, but is assumed to be of negligible dollar value, and is not considered further in this report from an economic point of view.

6.3 Complaints about Dusting

C.N. have advised that, in their experience, complaints about dusting are more frequent for train movements to the east across the prairies than to the west across the mountains, basically because of higher train speeds across the prairies. They have received only 5-6 complaints over the last year. The shipper and railway investigated each occurrence immediately and took remedial action in the form of double spraying. No further complaints have been received; and the shipper and railway believe that these problems have been satisfactorily resolved.

Citizen complaints prompted the Environmental Protection Service to conduct an investigation into coal dust emissions from unit trains travelling to terminals at Ports in southwest British Columbia. (Ref. 3 and 4). Heavy dusting from the travelling trains was reported, with coal dust being carried as far as houses in close proximity to the tracks.

7.0 COAL NOT EMPTIED OUT OF CARS

7.1 General

The dumping cycle does not totally empty the coal cars. Approximately 1 to 5 tonnes of coal have been reported remaining in some coal cars. This coal is carried back to the mine (probably with some dusting en route). It reduces the capacity available in the car for the next load, but costs the same amount of freight dollars to ship back down to the port again.

Part of the problem is the result of rain and snow accumulated within cars on the way back to the mine. Warm coal loaded on top of the snow freezes to the car. Coal which is wet when loaded into the car may also freeze to the car.

Coal which is wet or loaded into cars which contain rainwater does not flow readily out of the cars even in warm weather.

Some designs of car drains do not work well and must be manually actuated. This is difficult to do because the train is in continuous motion while loading and extra manpower would be required.

There has been some experimentation with various types of paint and lining for the interior of the car, but an acceptable solution has not yet been found by the railway and the industry.

8.0 EXISTING RAIL CAR COVER SYSTEMS

8.1 General

All of the existing covers of the rigid type used on rail cars have been designed for specific applications. None appears to be suitable for the coal unit train operation in Western Canada.

8.2 Gascoyne to Bigstone, North Dakota

Covers were especially constructed for the Bigstone Power Plant Project which burns lignite. Approximately 10% of the coal was blown out of the cars before covers were used. Suggestion for covers was by Bechtel.

The covers could be hinged on one side because the cars always move in the same direction. A scroll rail alongside the car picks up a special hasp on the covers and lifts it open for loading. The cover closes by gravity. A rubber tire presses the cover down at the exit to engage a spring loaded latch. At the power plant the covers are opened by the weight of the coal as the car is turned upside down.

The covers consist of five individual sections with an overlapping weather seal. The front cover opens first and closes first.

The covers weigh about 5000 lbs, are made of galvanized steel, pressed into shape. They are self supporting over the width of the car.

Cost of covers is approximately $3,500.00 per car.

Cars are 100 ton cars, 4,500 cu ft per car. Approximately 300 cars are in service. Cars and covers have been in service since approximately 1976.

Maintenance costs of these steel covers and the operating system have been low.

The system is designed such that it adds no additional time to the loading and unloading cycles.

This design would be difficult to adapt to loadout stations in Western Canada, since they do not have the required clearance for the opened hinged covers to pass through the loadout. The design would also be difficult to adapt to the existing dumpers in Western Canada since the cars are clamped from the top, and the clamping bar spans the top of the car, restricting movement of the cover. The dumper at Bigstone apparently clamps cars at the side rather than at the top.

Cars in Western Canada are turned end for end to equalize and minimize wheel wear; this would not be possible with hinged covers.

8.3 Stanray "Swing® Roof

Another type of steel roof is now being used for dry phosphate rock in Florida. It is proprietary product, steel, called the "Swing® Roof". This type of roof can be unloaded in either direction by rotary dumper. It is held on by latches on both sides of the car. As the car rotates, the roof shifts slightly to one side, unlatching on the lower side and swinging open as the car dumps. The roof returns to its normal position and centres itself when the car is righted. No scroll is required.

A method of removing the cover would have to be developed to be suitable for use in Western Canada as it would not pass through existing loadout facilities. This cover also would not open in the dumpers used on the West Coast because of the car clamps.

Weight and cost of this cover is not known at this time.

8.4 Rigid Fibreglass Covers for Concentrate Cars

Removable lift-off rigid fibreglass covers are being used on cars carrying ore concentrate to the West Coast.

These covers are one piece units, made of fibreglass, 5.0 to 6.3 mm thick, weighing approximately 1200 lb. All covers have lifting lugs at either end at a standard spacing. The covers cost approximately $2,100.00 each. Expected life is 10 years. Plate 3 and 4, Phase III Appendix.

The covers are supplied by the shippers. Each is a slightly different design, built to match a specific car.

Covers are held on to the car by guides and clamps of varying design; some types of clamps and guides are welded to the car, while others are attached to the cover. Plate 6 and 7, Phase III Appendix.

Covers are removed and replaced by a manually-operated gantry crane. Approximately 10 minutes per car are required to remove and replace the covers. Three men are required. Plate 5, Phase III Appendix.

Fibreglass is used because of its light weight and ease of repair. Covers have been blown about by the wind. Covers can be stacked about ten high. Covers presently used are being manufactured in Vancouver. These covers are not directly suitable for coal cars because of the amount of time required to remove and replace them for loading and unloading.

8.5 Flexible Fibreglass Plastic Covers

Flexible plastic covers are manufactured to cover narrow slot-type openings (24" wide) on top of some closed hopper cars.

These covers are not presently designed to span the entire width of a car, and would not appear suitable for coal cars without further development.

8.6 Wood Chip Car Covers

Rigid fibreglass covers are used on some wood chip cars. These have a slot down the length of the cover for filling. The covers are not removed for unloading bottom dump cars.

8.7 Sherman Mines, Temagami, Ontario

These covers were designed especially for barrel-shaped hopper cars carrying pellets.

8.8 Strachan & Henshaw System

In 1977 British Columbia Rail studied the use of covers on coal cars. (Ref. 1).

The equipment required to handle the covers both at the mine site and at the terminal was designed by Strachan and Henshaw of Bristol, England. At the terminal as the uncoupled car is located in the dumper, an hydraulic arm picks up the fibreglass cover and replaces it when unloading has been completed. The major difficulty of this English design is that its pivoting axis does not coincide with the axis of the rotary coupler and therefore cannot be readily applied to existing rotary dumping equipment in Canada, where the cars remain coupled in the dumpers. In addition, longer turn-around times are experienced with the English system. Following the study by B.C. Rail, the railroad's use of covers was de-emphasized in favour of more conventional spraying practices.

9.0 PROPOSED COVER DESIGN PARAMETERS

9.1 General

This section consists of a number of ideas, constraints and comments, which will affect the eventual design approach for a rail car cover, cover handling system, and may indicate possible modifications required to existing loadout and dumping facilities to accommodate covers and their handling systems.

9.2 Cover Dimensions

- As few different sizes and variations as possible.

- Preferably one cover which will fit all cars; reduces spare stock; reduces confusion; allows substitutions from one car to any other, even with automated handling equipment.

9.3 Cover Weight

The payload of each car is reduced by an amount equivalent to the weight of the cover and other attachments.

CONCLUDE: the cover must be as light as possible, and hinges, clamps, and attachments must also be as light as possible.

9.4 Cover Material

A compromise will be necessary to obtain the most effective cover.

Considerations in selection of materials:

- weight,
- strength,
- flexibility; rigidness,
- cost,

- manufacturing facilities, complexity, ease of molding and fabrication, local availability, time required to manufacture, ability to manufacture in quantity,
- resistance to impact and rough handling,
- resistance to cold,
- resistance to heat,
- ease of repair of damage,
- coefficient of thermal expansion,
- compatible with thaw shed operation,
- resistance to sunlight (ultra-violet)
- colour selection, logos, insignias,
- resistance to rain and weather,
- resistance to salt,
- resistance to other forms of corrosion.

Possible Materials:

- steel, mild, galvanized, painted or stainless,
- aluminum, high-strength,
- mangesium,
- fibreglass,
- other forms of rigid or semi-rigid plastic, pvc, etc.,
- fabric, canvas, reinforced, rubberized, or plasticised,
- plastic film,
- spray-on material.

9.5 Cover Shape

- arched or ribbed to span width of car,
- arched or with sidewalls high enough so that cover will clear highest level of coal in car at loadout facility, as the top of the coal is above the top sills of some cars at the time the car is filled.
- arched or sloped so rain will drain off,
- low profile, at least so top of cover when placed on highest car is still lower than loco or caboose,

- configuration and ribs arranged so that covers can be nested or stacked,
- aerodynamic considerations, longitudinally to minimize drag,
- aerodynamic considerations, to minimize uplift from longitudinal and/or lateral winds,
- lips overhanging edge of car, to prevent or minimize entrance of water or wind under edge of cover into car,
- symmetrical, so cover can be placed on car with either end to the front,

9.6 Cover Type

- rigid; steel, aluminum, fibreglass,
- air supported, inflatable,
- flexible; canvas, film,
- disposable; film, spray-on material.

Various cover types are depicted on SK004 - SK014 in appendix.

9.7 Cover Mounting

- hinged on one side, latched on the other, SK004, SK005; this cover must always enter the dumper in the same direction with the hinges on the off side so the cover can swing open in the dumper; and must always enter the loadout so the hinges are on the off side so the operator can see the loading chute;
  CONCLUDE: not feasible since cars are sometimes reversed, and all load-out and dumpers are not of the same orientation.
- hinged on both sides with combination hinge-latch (Swing®Roof), (see appendix);
- clamshell covers, SK006, SK007, attached to each side of car; consider wear and forces on cover by coal and frozen material cascading over the cover in the dump; consider blocked visibility within loadout; most suitable material may be steel;
- folding covers, folding to the side; consider interference with dumper clamps; ice and snow hampering operation, method of powering cover open and closed;

- folding covers, SK008, SK009, concertina style folding towards ends of cars; interference of dumper clamps with cover guide rails, ice and snow hampering operation, method of powering, require clearance between cars so indexer pusher arm does not contact folded cover;
- roll up cover, same difficulties as above;
- pivoted cover, SK010, which swings down to either side beside car; consider side clearances when passing through dumper and loadout.
- lift off and carry around loading and dumping facility;
- combination hinge and lift-off clamp, which can hinge or release cover on either or both sides;
- covers hinged both sides and secured with sections which are removed for loading and dumping operations, SK011;
- 3 section cover, SK012, SK013, lifted off while in dumper before the car is turned over; consider increase to cycle time if cover must be lifted off and replaced while car is in dumper; operator has full view and control of operation at the dumper.

9.8 Thaw Sheds

- covers must be suitable to pass through thaw sheds, unless they are removed,
- removing covers entails storage, which entails handling and stacking, which may be difficult to automate.

9.9 Mods to Railway Equipment

Railway equipment is mostly existing. Type of car is fixed (rotary dump gondola). Many variations exist, and more variations in car types and dimensions can be expected in the future. Considerations are:

- must be able to retrofit lid,
- must outfit all cars that might possibly be used for coal with appropriate fittings or mods to enable lids to be placed or removed from service at any time,

- power operation for cover if required; tap air supply from brake reservoir?
- lateral cover supports, stays or guides cannot be installed; loadout chutes project into some cars; chunks of frozen coal would distort or damage such supports.

Latches, Latching, and Unlatching

- imperative that unlatching and latching does not stop nor slow down the train,
- required mechanized equipment to unlatch and latch,
- equipment to operate unattended,
- recognize a latch failing to open before ripping the cover off; sound and log alarm,
- recognize a latch failing to close when cover is replaced; sound and log alarm,
- latches will be at different heights from top of rail,
- failsafe locking,
- manual override to open and close; for access for inspection or correction of weight of load.

9.10 Cover Handling System

- must clear locos and caboose, recognizing them automatically,
- must lower to car height,
- must unlatch, remove, transport, replace, and relatch covers,
- must work in any weather, even if latches iced up or cover is frozen to car,
- must wash or sweep coal off top of car before replacing cover, to ensure fit and seal and re-engagement of latches,
- must not be affected by wind; lifting jig must position precisely,
- recognize broken or defective cover; discard it; pick up a new lid from stockpile, and insert into the sequence.

10.0 DISCUSSION

10.1 Responsibility for Covers

The railways indicate that they would limit their responsibility to the operating of train sets, scheduling, and equipment pooling. They would not hold themselves responsible for equipping, maintaining or handling covers, en route, at the mine loadout or at the terminal, These responsibilities will be assumed by the shippers and terminal operators.

10.2 Handling Covers at Terminal

Trains arriving at the terminals with covers will not have the sprayed topping. These cars will be subject to dusting by the wind if the covers are lifted off prematurely.

CONCLUDE: covers should be opened only when the car is very near the dumper, perhaps even inside the building. Existing buildings may have to be enlarged, or a wind screen provided.

10.3 Washing Cars

Presumably covers would be replaced and washed with the car. Moisture between the cover and the car could cause the cover to freeze to the car.

CONCLUSION: Use non-absorbent seal.

10.4 Temporary Covers

If a cover is lost en route, would the train have to stop? Would a temporary cover (plastic film) be required for the remainder of the trip? Who would install it? Who is liable?

10.5 Covers Through Loadouts

Drawing Numbers SK-004 to SK-007 in the Appendix illustrate a typical load-out station with the coal car passing through. Depicted on the coal cars

are three different covers of the non-removable type. Areas of conflict between the loadout structure and the opened car covers occur in cases where the covers are hinged one side (SK004; SK005), and although the clam-shell type cover shown in SK006 and SK007 does not interfere with any major structural members of the loadout station, there would be severe restrictions at the terminal where this type of cover would interfere with the rotary dumper platen and dump bars (SK015, Phase II Appendix and SK037 Phase III Appendix).

10.6 Costs Attributable to the Covers

The payload of each car is reduced by an amount equivalent to the weight of the cover. Thus more car trips will be required to move the same amount of coal. Additional unit trains will probably be required, and these additional trains will take up time-space at the loadout stations, on the rail system, and at the unloading terminal.

The additional difficulties with the covers or the handling system, or any time required to handle covers which results in an increased cycle time for a unit train trip, is ultimately reflected in additional train capacity, additional time-space requirements, and additional costs.

Parts of the rail and port system are operating at capacity now, and the system cannot presently accommodate any delays. One of the mines has commented similarly re their loadout system.

If loadout silos are to be modified to accept covers that are hinged one side, major structural changes would have to be undertaken to the silo support structure at substantial cost.

Costs attributable to the covers are calculated in the economical analysis in Phase III of this report.

The costs are eventually reflected by increased port charges, increased freight charges, and would eventually be borne by the shipper-producer along with the costs of the covers and handling system required at the shipper's own loadout.

SUMMARY

The major conclusions evident from the design parameters are as follows:

- light as possible,
- inexpensive as possible,
- rugged, durable, resilient,
- cover hinged on one side only is not acceptable to dumper,
- cover cannot go through all loadouts; therefore must lift off and carry around loadout,
- the train cannot be slowed down nor stopped for unlatching, removing, replacing, and relatching covers if present loading speeds and equipment utilization are to be maintained,
- one size to fit all cars,
- automatic removal and replacement, fail-safe with alarms,
- cover handling system must operate with train in-motion.

REFERENCES

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2. C. Guarnaschelli, "In Transit Control of Coal Dust from Unit Trains", Fisheries and Environment Canada, EPS-4-PR-77-1, May, 1977.

3. Fugitive Coal Dust Emissions from Coal in Railroad Cars. - Observations from Western Canada, March, 1980. D. L. Cope.

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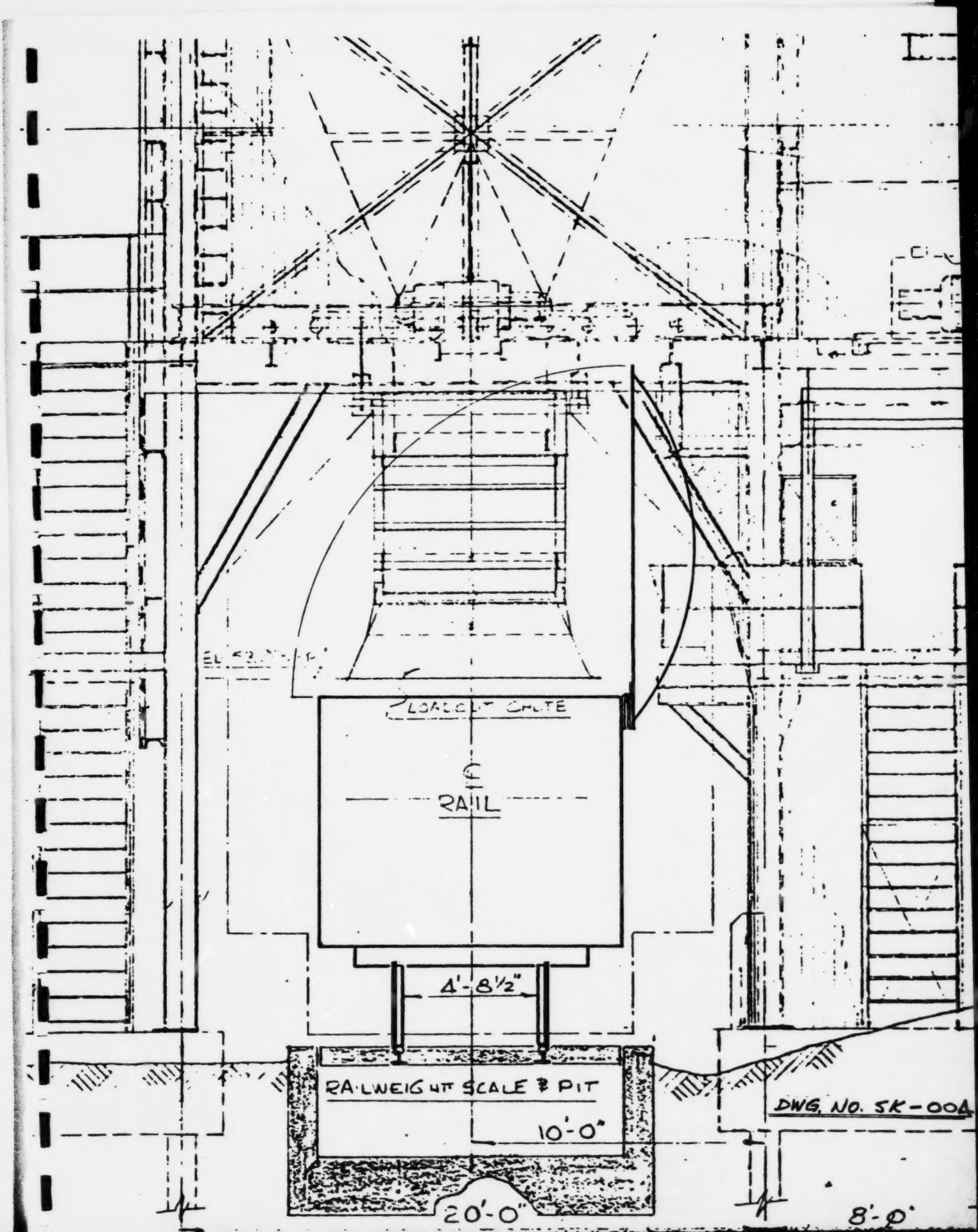
5. M. M. Papic, A.D. McIntyre, "Surface Active Agents in Coal Dust Abatement", p. 85, Coal Age, June, 1973.

6. B.H. Levelton, A.J. Shaw, E.A. Williams. "Measurement of Crust Remaining on the Surface of Coal Cars on Arrival at Dumping Terminals" - Result of Monitoring 30 Trains. Prepared for Federal Activities Abatement Group Environmental Protection Service, October, 1975.

7. C. Guarnaschelli, "Coal Dust Control on Unit Trains". Environmental Protection Service - September, 1975.

8. Beak Consultants Ltd., Hardy Associates Ltd., Sandwell and Co. Ltd., Swan Wooster Engineering Co. Ltd. "A Study of Coal Dust Contamination of Canadian Cellulose's Watson Island (Prince Rupert) Pulp Mill from the Operation of a Coal Terminal on Ridley Island and Coal Unit Train Access and Egress to the Proposed Terminal" Phase One: Problem Definition - December/79, Phase Two: Mitigating Measures - September/80.

APPENDIX A - Preliminary Cover Designs
- Restrictions of Typical Layout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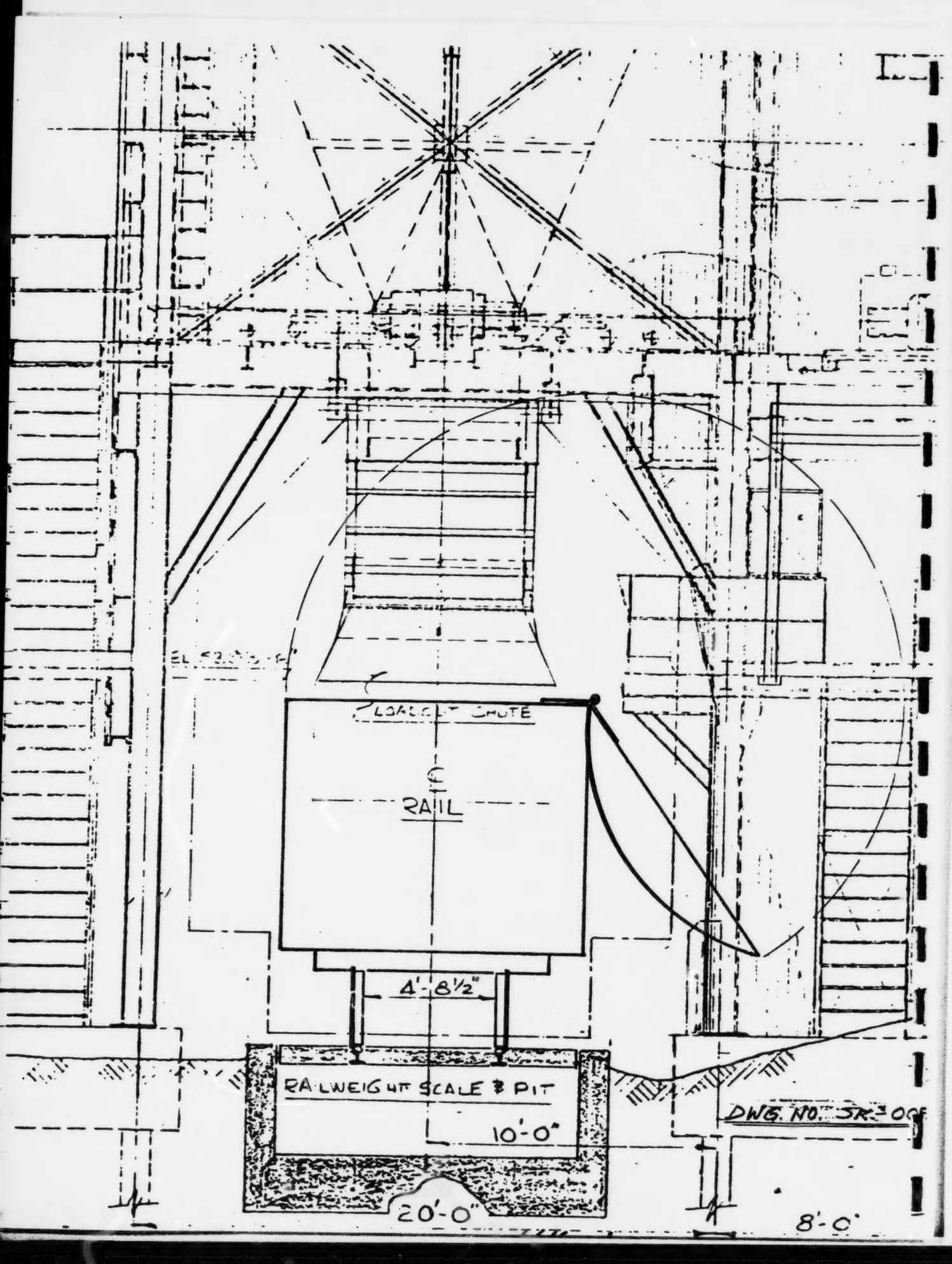
DWG. NO. SK-004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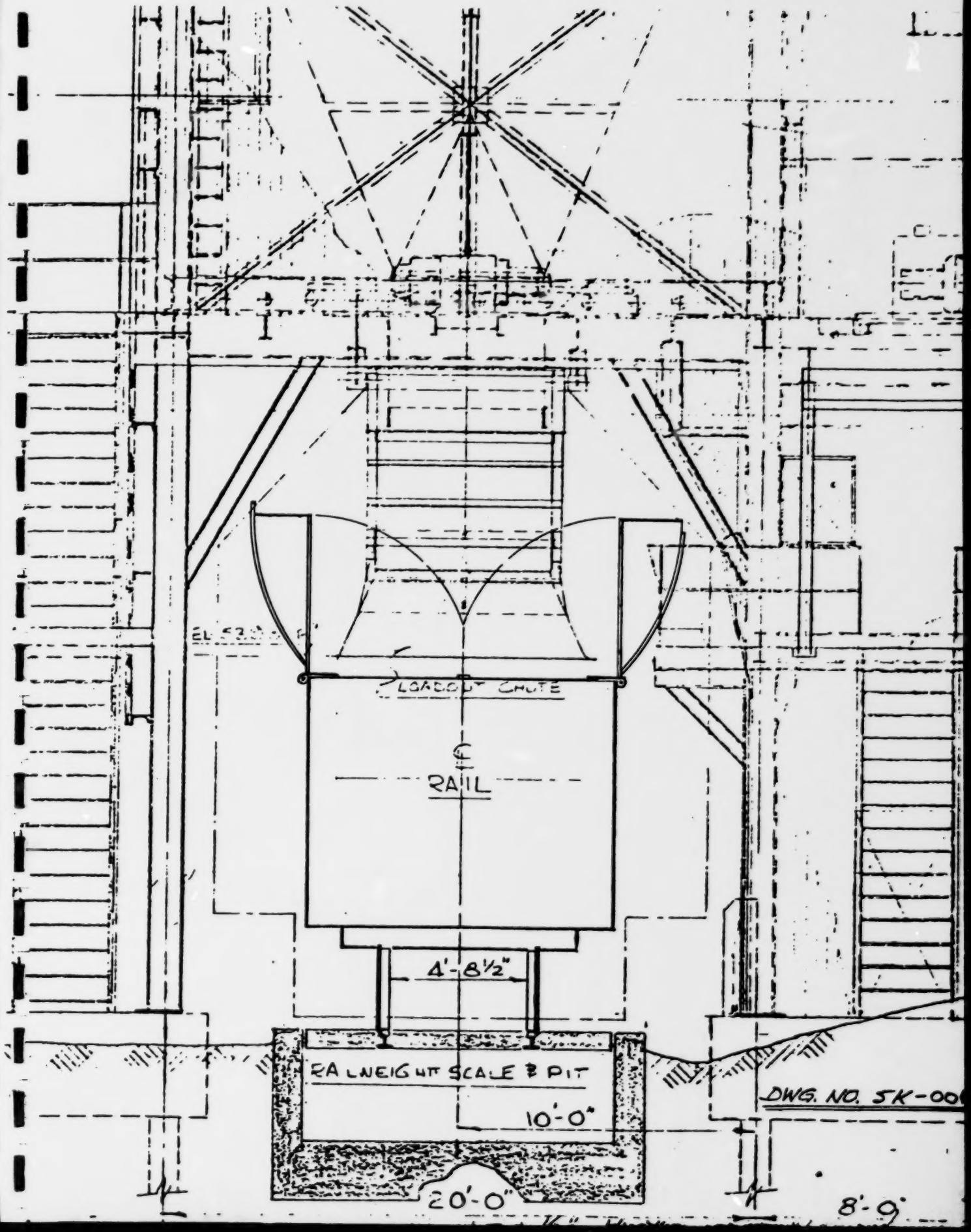
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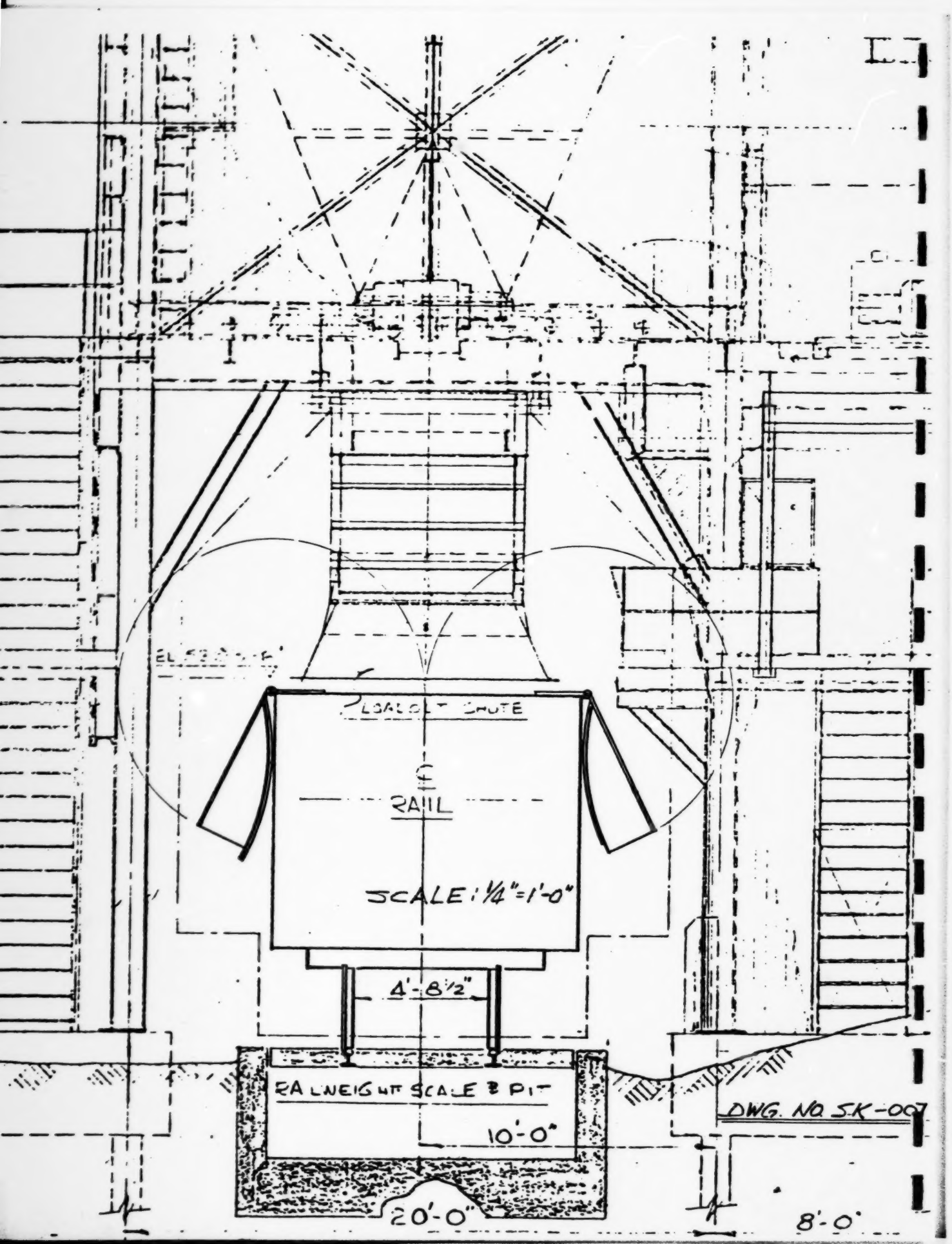
DWG. NO. 5K-00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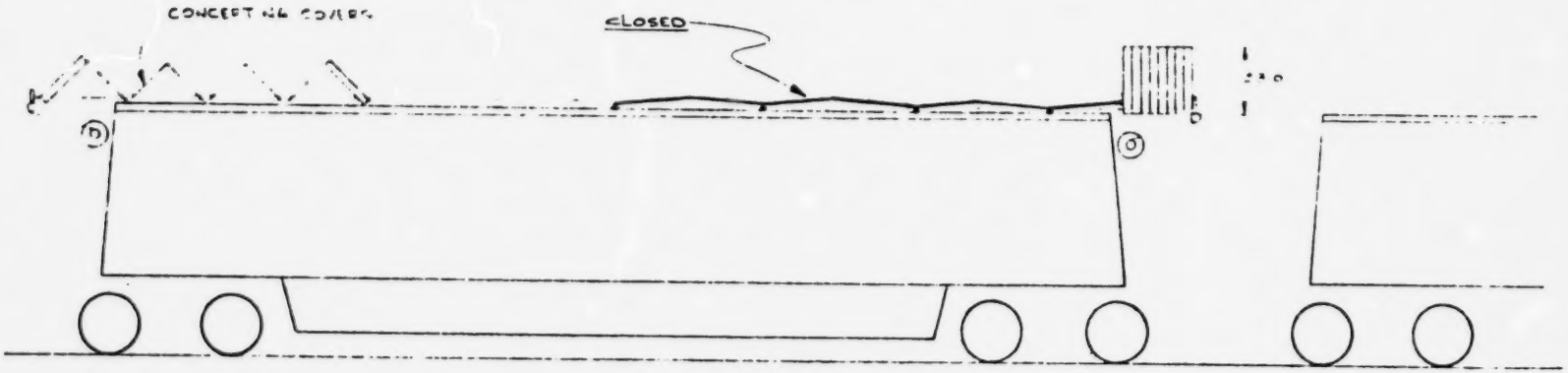


ADVANTAGES.

① COVERS NEVER LEAVE CAR. IT DOES NOT MATTER WHETHER CAR OF DIFFERENT SIZES ARE MIXED UP IN TRAIN UNIT.

② NO EXPENSIVE LIFTING OFF/ON EQUIPMENT & STRUCTURES.

③ IF DAMAGE OCCURES IT IS LIKELY THAT ONLY A SECTION OF COVER NEED BE REPLACED NOT COMPLETE COVER.

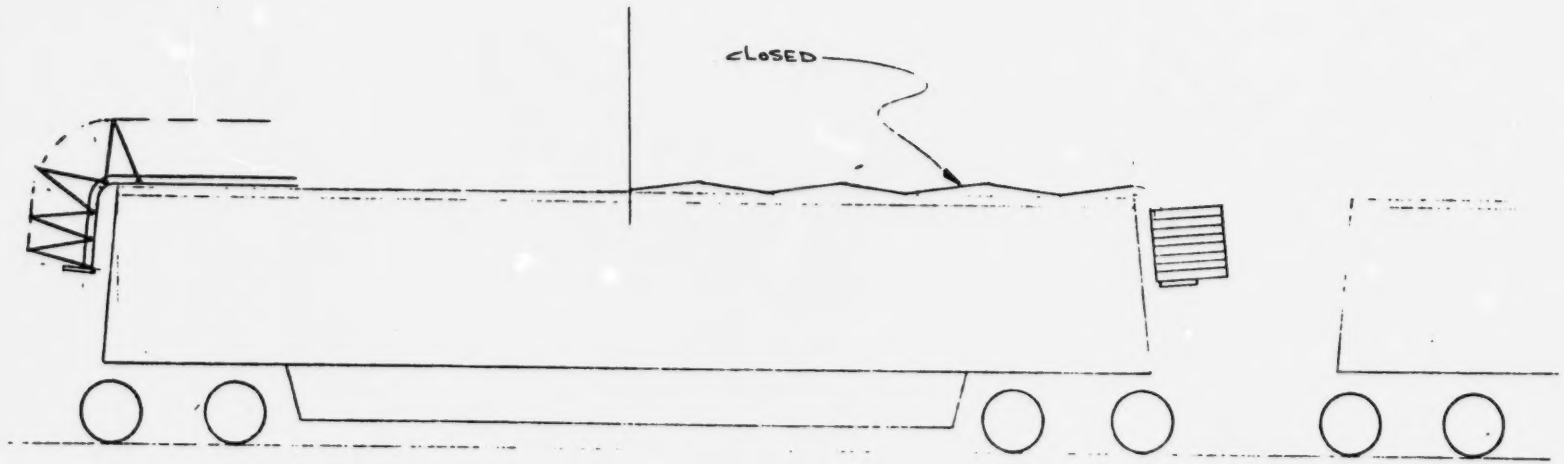
DISADVANTAGES.

① CAN FOLDED SECTIONS FIT INTO ½ SPACE BETWEEN CARS.

② CAN LOADOUT CHUTE BE RAISED TO CLEAR FOLDED SECTIONS AT EACH CAR.

DWG. NO. SK-008

SCALE 3/16" = 1'-0"



ADVANTAGES.

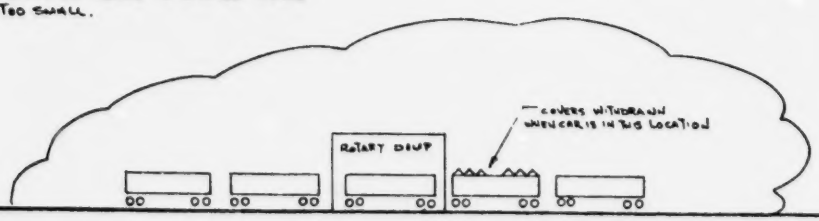
① COVERS UNDER LEAVE CARS THEREFORE MIXED GRADES IN A TRAIN ARE NO DETRIMENT.

② NO EXPENSIVE HANDLING EQUIPMENT

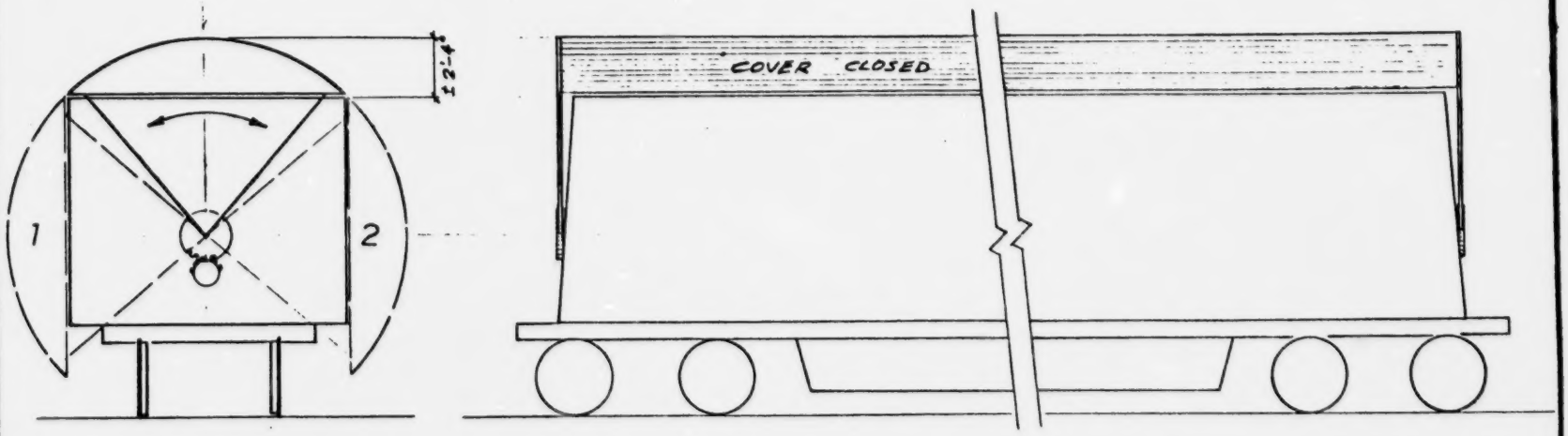
DISADVANTAGES & OBJECTIONS.

① IS THE SPACE BETWEEN CARS SUFFICIENT?

② BECAUSE OF LIMITED STACKING SPACE THE HEIGHT OF COVERS IS LIMITED. MAYBE TOO SMALL.



DWG. NO SK-009



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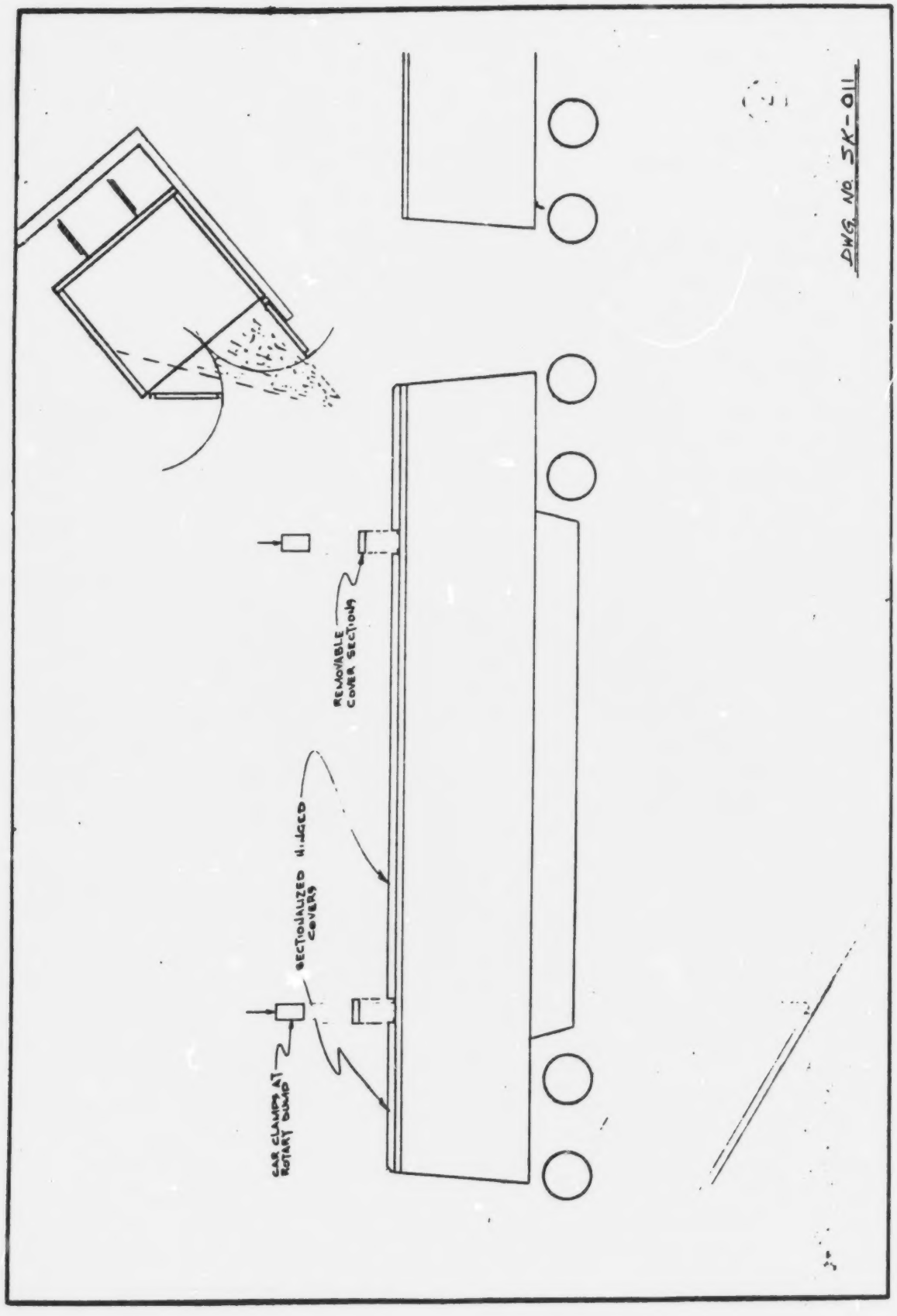
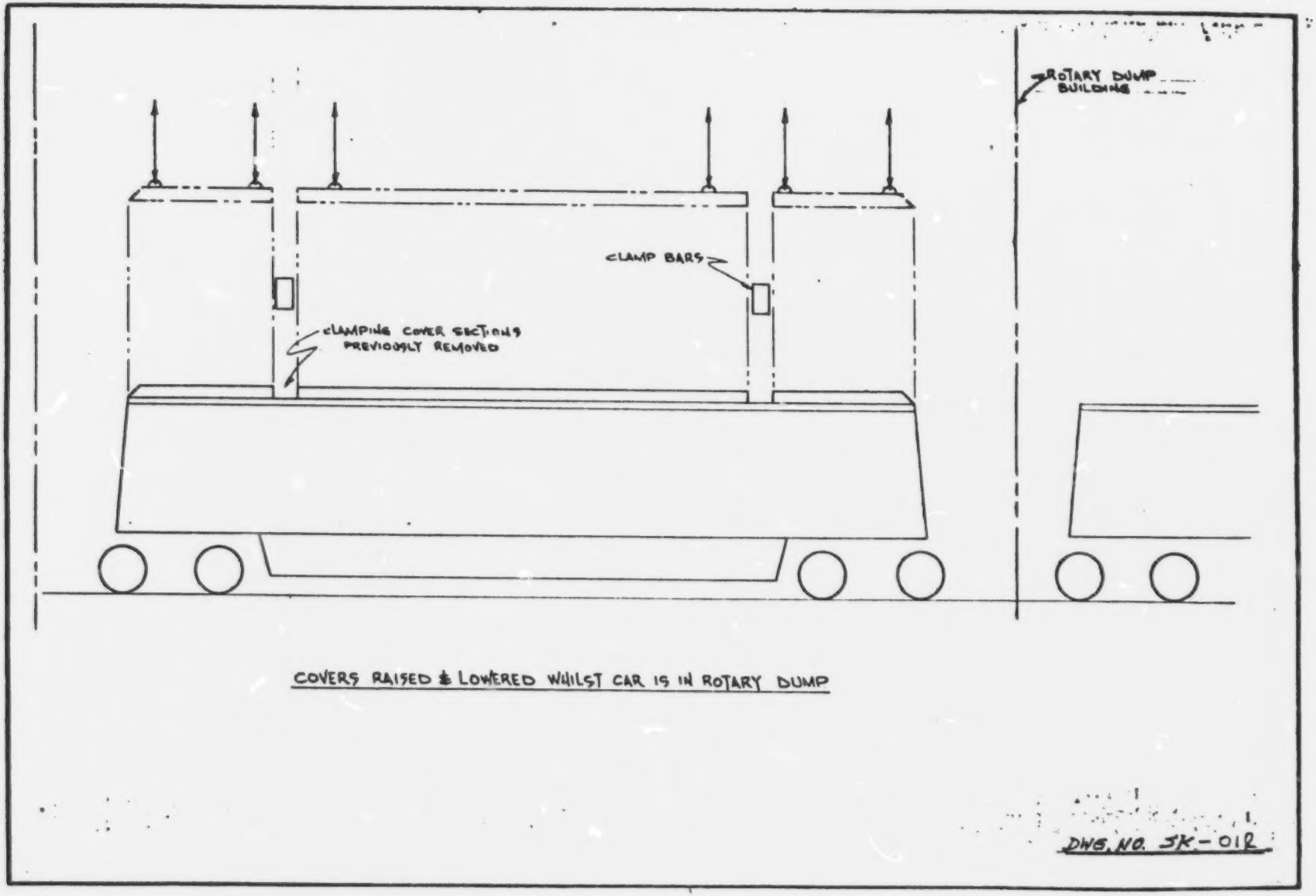
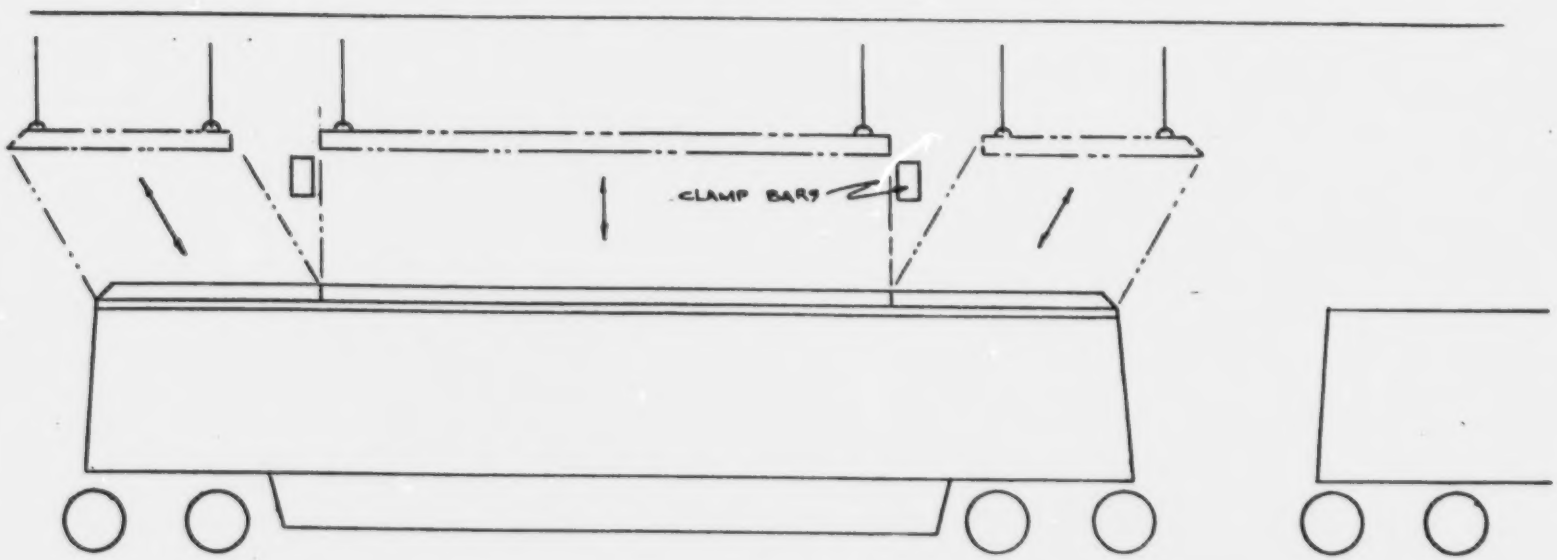

DWG. NO. SK-011
REMOVABLE COVER SECTIONS
SECTIONALIZED HINGED COVERS
CAR CLAMPS AT ROTARY DUMP



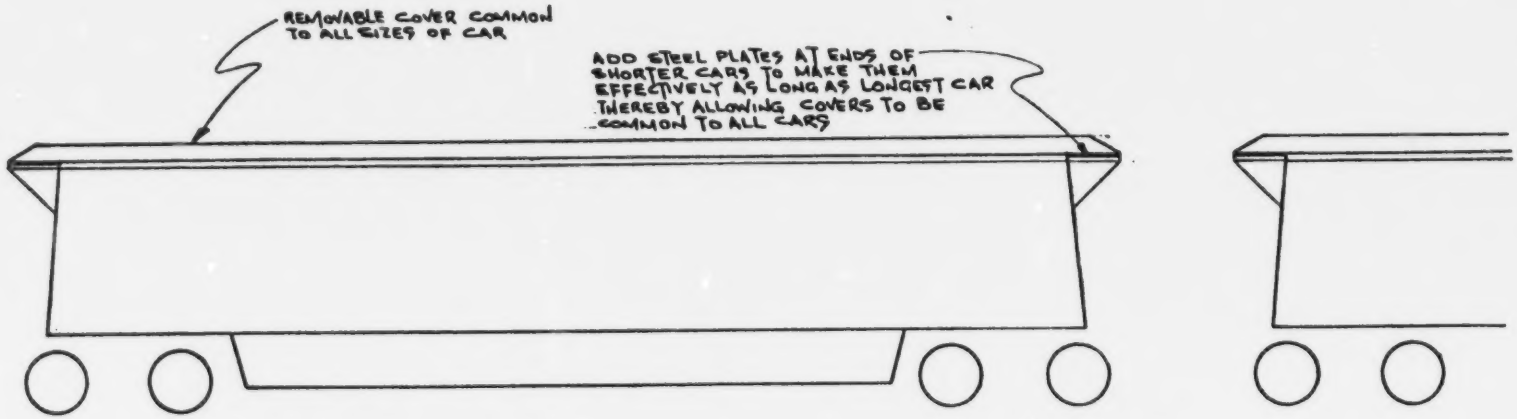
COVERS RAISED & LOWERED WHILST CAR IS IN ROTARY DUMP

DWG. NO. 3K-01R



COVERS RAISED & LOWERED WHILST CAR IS IN ROTARY DUMP

DWG. NO. SK-013


REMOVABLE COVER COMMON TO ALL SIZES OF CAR
ADD STEEL PLATES AT ENDS OF SHORTER CARS TO MAKE THEM EFFECTIVELY AS LONG AS LONGEST CAR THEREBY ALLOWING COVERS TO BE COMMON TO ALL CARS

DWG. NO SK-014

APPENDIX B - Existing Cover Systems

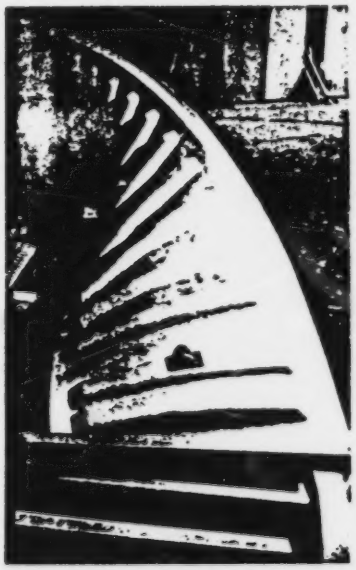
Ribbed design of hatch cover adds rigidity.

Hopper car covers molded for rough use on railroads

■ Steel hopper cars on some U.S. railroads are now sporting hatch covers made of glass-fibre-reinforced plastic.

Produced by Cobalt Boats, a leading molder of FRP pleasure craft in Neodesha, Kansas, the Endura-Cover units were introduced to the market last fall as part of a program of diversification by the company.

The covers were developed over a six-month period during which time they were put through a variety of performance tests — for resistance to "twisting", to impact-type pressure, to mechanical "slamming" in an extended opening and closing operation, and to determine their resistance to structural damage while being forced shut with a blockage in the hinge area.



During development, the covers were tested for resistance to twisting.

Cobalt molds the covers by sprayup, reinforcing the outer flanges and the hinge areas with layups of glass cloth.

A special rubber bumper is fitted to each cover to absorb impact when it is thrown open.

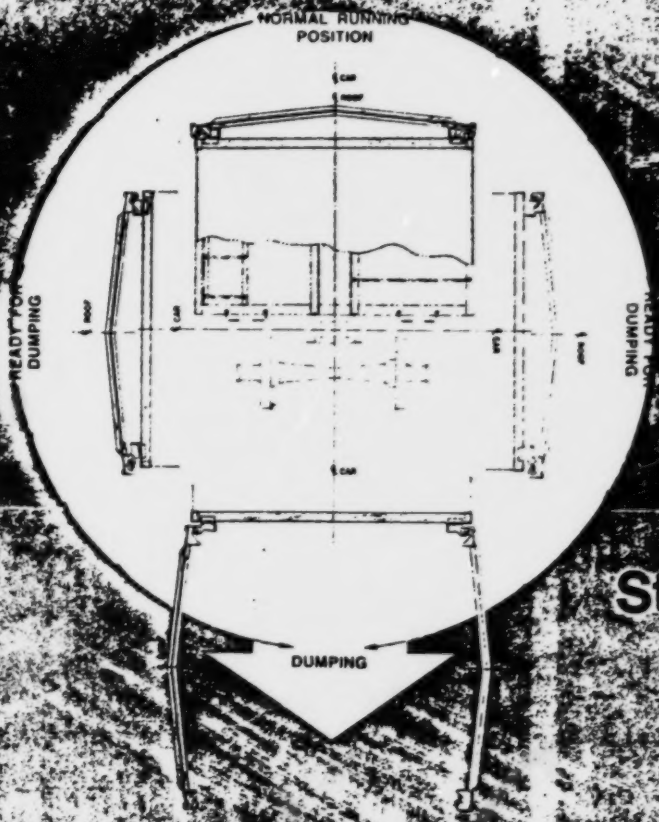
The outside of each cover is finished with a colored marine-grade gel coat with built-in UV resistance.

A heavy-duty rubber gasket assures a dust-proof and water-tight seal around the car's coaming.

A series of ribs along the length of each cover add rigidity

Endura-Covers are made in six standard styles for the different hopper car openings.

Any molder in Canada wishing to produce the covers under a licensing or joint-venture agreement is invited to contact the company's sales manager, Jerry Goodwin.



Stanray swing roof

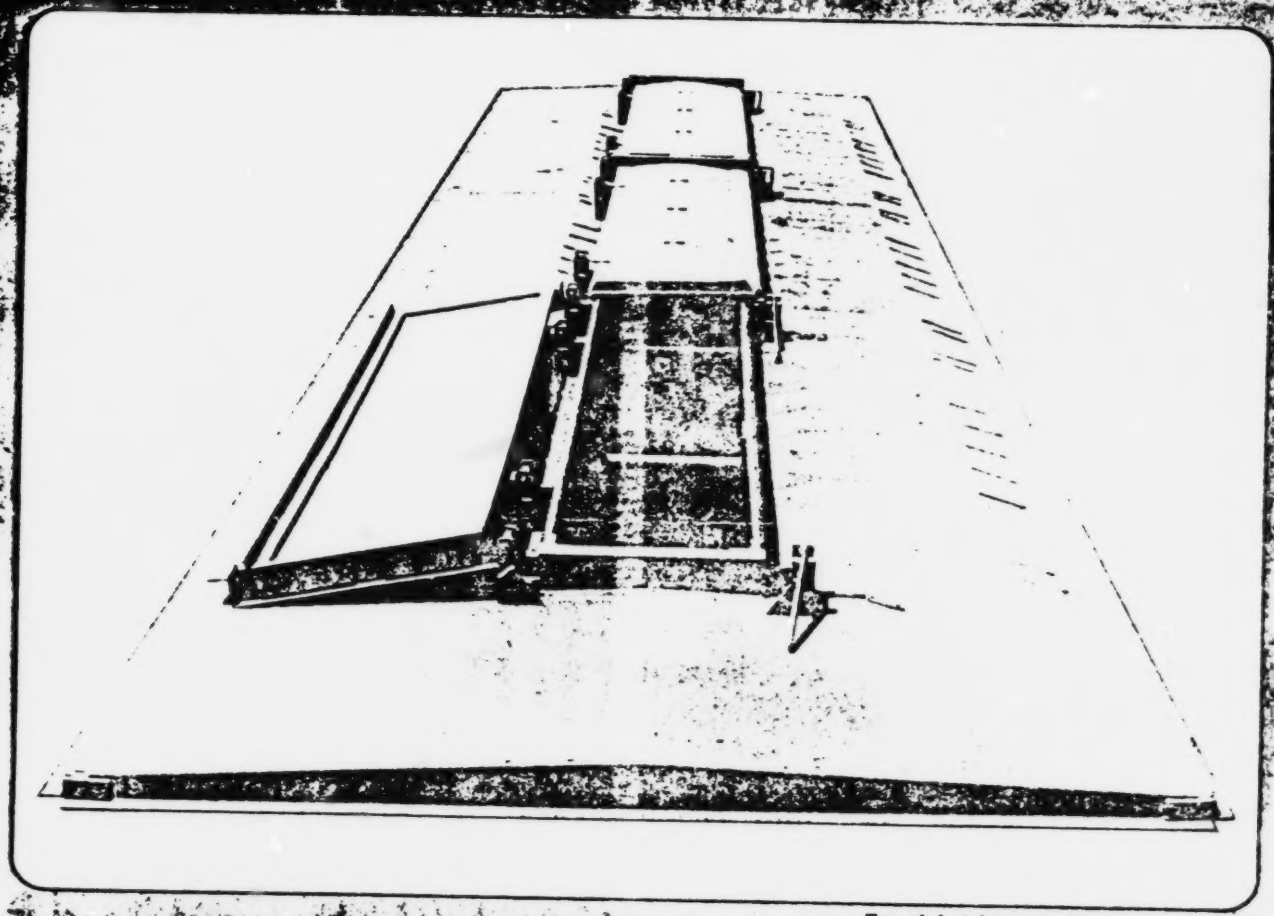
Stanray Corporation designed the exclusive Swing Roof, an entirely new concept developed to fill the need for covered cars where lading must remain absolutely dry. The Roof, with hinges on both sides, can be opened from either side by rotation in a rotary car dumper.

A rotary car dumper is used where a large volume of material is unloaded instantly, with a minimum amount of labor. The Stanray Swing Roof, applied to a high side gondola or open top hopper car, provides a method of shipping "dry" materials along with the economy of rotary dumping the car.

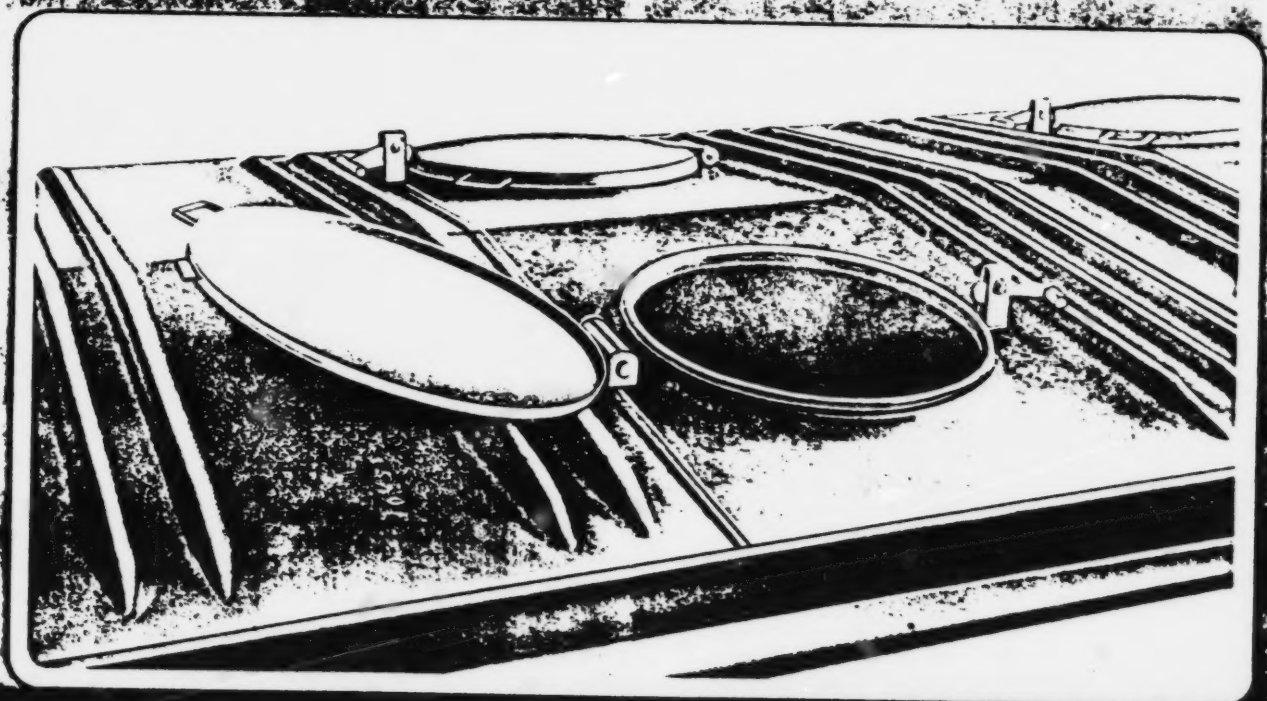
Simplicity of design and construction was a major consideration in the development of the Stanray Swing Roof. The revolutionary Swing Roof is held to the car by gravity when in normal running position. Due to the unique contour of the hooks, they automatically lock to either side of the car when the Roof is open more than 15 degrees during dumping. Maximum opening for the Roof is a full 120 degrees.

Using the basic concept of moving large quantities of "dry" materials in covered cars with the Swing Roof, and unloading in a rotary car dumper, it can readily be seen that exceptional economics can be achieved with this greatly simplified method. The Swing Roof has only one moving part: the Roof itself. There are no slope sheets or complicated hatches (maintenance is automatically reduced as the number of moving parts is reduced). In addition, the total weight of the car is considerably decreased.

STANRAY CORPORATION
Standard Railway Equipment Division
200 South Michigan Avenue, Chicago, Illinois 60604, (312) 939-3450



Trough-hatch removable hopper car roof



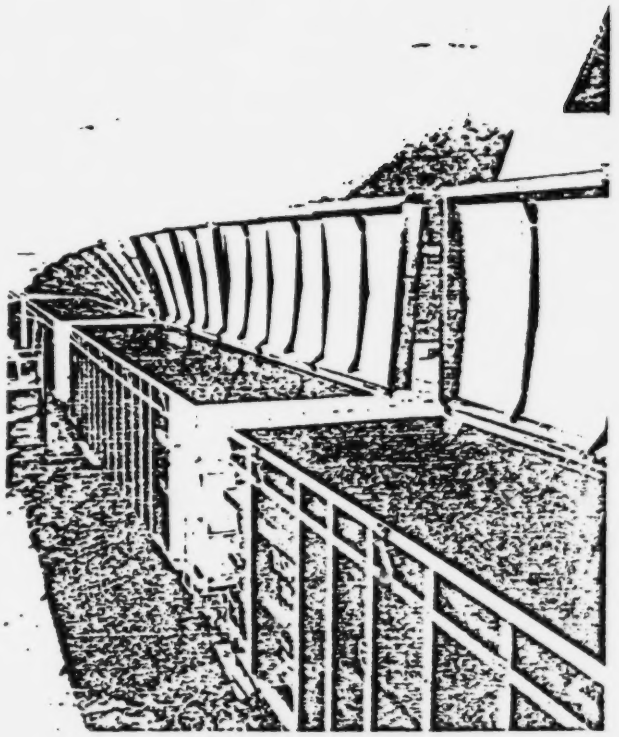
miles) in length. Production is scheduled to keep the 24-m³ (32-cu yd) dragline moving from pit to pit in sequential order; a full circuit around all four pits requires the dragline to walk about 21 km (13 miles). Mine personnel cite time-consuming repairs on the walking mechanism as a fairly regular problem, but overall performance of the dragline on a 15 shift per week basis is good.

Coal is loaded ten shifts a week with either a 14-m³ (18-cu yd) shovel or, for pit mobility in blending operations, a Caterpillar 992B that has logged over 6000 hours with no major breakdowns. A prototype coal ripping and loading machine, built by Huron Mfg. Co., is also being used at the mine. The all-hydraulic Easi-Miner rips intact coal from the seam and loads it out at 450 t/h (500 stph) into a truck running alongside the discharge conveyor. Results thus far are good, although accuracy in cleanly cutting lignite from the underlying waste is sometimes difficult to control. Gascoyne also uses the Easi-Miner for taking topsoil, removing partings, and building roads.

The mine's five 100-ton trucks use Mack tractors pulling bottom dump Darby trailers built to Knife River specifications—other trailers suffered structural damage from the heavy load weight of wet lignite. Cold North Dakota winters caused air system problems until maintenance personnel switched the trailers to hydraulically-operated doors.

Three seams with a composite thickness of 9 m (30 ft) are mined in the Harmon bed. Life-of-mine overburden is calculated at 13 m (42 ft) with an extremely variable parting (0.6 to 6.7 m/ 2 to 22 ft) between the top two seams and a consistent 560 mm (22 in.) parting between the botom two. Leonardite, or "slack", occurs naturally at Gascoyne where a lignite seam lies close to the surface. Although common throughout North Dakota, only at Gascoyne is the oxidized lignite mined as a by-product. Over 100,000 tons each year are hauled a few kilometers to the American Colloid Co., an NL Industries subsidiary, where it is dried and marketed as a drilling mud additive or soil conditioner.

Run-of-mine coal is reduced to minus 75 mm (−3 in.) in McNally-Pittsburgh roll crushers and conveyed to a 29 000-t (32,000-st) stockpile. A 108-car unit train is loaded six days every week for the 357-mile trip to Big Stone, S.D. Average loadout time is 3 hours 10 minutes. The 100-ton cars, designed by Bechtel, have self-opening and closing lids covering them to prevent loss of fines when traveling loaded and snow accumulation when returning empty. The covered unit coal train, the only known one of its kind in the world, also prevents the already wet lignite from getting any wetter during transit.



Bechtel-designed coal cars with self-opening and closing lids solve lignite transportation problems at Gascoyne mine.

Gascoyne's labor force is organized as Progressive Mineworkers; all employees except three were recruited from the local area. This created training problems when the mine underwent its major expansion, notes mine superintendent Frank Eide, but the result now is a stable workforce maintaining a dependable operation.

Center Mine (Baukol-Noonan): Full Production after a $24-Million Expansion

Baukol-Noonan Inc. has been gearing up for a large production increase at Center mine since mid-1974, when it signed a 50-year coal sales agreement to supply over 3.6 million t/y (4 million stpy) to a minemouth electrical generation complex operated by Minnkota Power Cooperative. The new 400-MW Square Butte plant went on line May 5, complementing the already existing 235-MW Milton R. Young plant—and Center mine was ready to meet the increased demand with entirely new mine facilities and equipment.

A $12-million Page 757 dragline with a 48-m³ (68-cu yd) bucket was delivered in early 1976. Since Center has no railroad spur, each component was trucked into the property from the nearest rail point, about 40 km (25 miles) away. Dragline construction was completed in July 1977, the final step in Center's $24-million expansion that brings it to full production capabilities.

Other new equipment includes a Marathon Letourneau L800 17-m³ (22-cu yd) wheel loader for in-pit blending of lignite to the desired heat content, a P & H 1900 14-m³ (18-cu yd) loading shovel, and four 180-ton Unit Rigs. A new office/maintenance complex was also built which will garage the trucks and wheel loaders during the cold North Dakota winters.

Two seams, with a combined thickness between 2.4 and 6.7 m (8 and 22 ft), are mined from the Hagle bed. Where erosion missed some areas on the property, a third seam shows up, but it is too weathered to be marketable. Aver-

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APPENDIX C - Production and Shipping Information of Mines in Western Canada

MINE & ADDRESS	TONNES/ANNUM PRODUCED	HOW SHIPPED	SHIPPED TO	DISTANCE	LIFE EXPECTANCY OF MINE	MINE MANAGER		
BIENFAIT MINE BIENFAIT, SASKATCHEWAN	1980 ½ MILLION TONNES EXPECTED PRODUCTION - 2 MILLIONS IN 1981	BY CNR & CPR	SASKATCHEWAN MANITOBA & ONTARIO			S. HOUSDORFF		
MANALTA COAL LTD. KLMAX MINE ESTEVAN, SASKATCHEWAN	1979 545,000 TONNES 1980 718,000 TONNES	TRUCK CNR & CPR	DOMESTIC MARKETS			H. BOLES		
COAL VALLEY MINE EDSON, ALTA.	1980 2.3 MILLION TONNES	CNR	ONTARIO & OFFSHORE			S. JONES		
DIPLOMAT MINE FORESTBURG, ALTA.	1980 - 0.8 MILLION TONNES	CNR	ALBERTA B.C. SASKATCHEWAN & MANITOBA			O. SABOE		
LUSCAR MINE NINTON, ALTA.	1980 2.5 MILLION TONNES	CNR	WEST COAST TERMINAL			H. MYERS		
MCINTYRE MINE GRANDE CACHE			WEST COAST TERMINAL					
MANALTA COAL LTD. ROSELYN MINE SHEERNESS ALTA.	1979 172,000 TONNES 1980 77,000 TONNES	TRUCK & CNR	DOMESTIC MARKET			D. MEADS		
FORDING RIVER MINE ELKFORD, B.C. V0B 1H0 FORDING COAL LTD.	1980 3.57 MILLION TONNES	CPR	WEST COAST TERMINAL	± 650 MILES		J. G. GARDINER		
B.C. COAL LTD. DHARMER MINE SPARWOOD B.C.	1980 - 2.87 MILLION RAW LONG TONS	CPR	WEST COAST TERMINAL	± 650 MILES		L.W. RIFFEL		
MICHEL UNDER-GROUND MINE SPARWOOD B.C.	1980 - 0.774 MILLION RAW LONG TONS	CPR	WEST COAST TERMINAL	± 650 MILES		J. ANDERSON		

PHASE TWO - REPORT

FOR

AIR POLLUTION CONTROL DIRECTORATE
ENVIRONMENT CANADA

Feasibility, Cost and Conceptual Design Study of Automated Coal Car Cover Systems Designed for Abatement of Fugitive Coal Dust.

DSS File No. 40SS.KE145-1-0458.

March 10, 1982

PHASE TWO

EVALUATION, SELECTION AND CONCEPTUAL DESIGN OF AUTOMATED COVER SYSTEM

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1.0 INTRODUCTION

PHASE TWO - REPORT

Background

The purpose of this report is to present the technical and cost feasibility of equipping Canadian rail coal cars with an automated loading/unloading cover system designed to abate all fugitive coal emissions.

The report is being undertaken at the request of the Department of Supply and Services for Environment Canada. The final report will be submitted to the Scientific Authority on or before March 15, 1982.

The report is to be undertaken in three phases, the first comprises background and information research, the second comprises an evaluation of conceptual designs and a selection of the most promising alternative. Phase three will be the final report and will include phase one and phase two plus an economic evaluation of cover systems in use on a typical coal transportation system.

This report addresses the second phase of the work.

2.0 PROPOSED COVER DESIGN

2.1 General

This section consists of a number of ideas, constraints and comments which influenced the selection of the most promising cover design.

We have concluded that to overcome the many problems, major reconstructions and modifications to loadout facilities and terminal equipment that would be necessary if permanently attached covers were installed to the coal cars, to minimize the forfeiture of coal in each car due to the weight of the cover, and to provide a cover that would fit all coal cars in the unit train service irrespective of size, a fibreglass reinforced polyester cover of the lift-off, carry around and replace type would be the most desirable. However, for a future coal unit train system where there are no restraints due to existing loadouts or terminals, an attached hinged cover may be preferable.

An economic analysis of attached hinged cover systems applied to a future coal unit train system will be undertaken in Phase III of this study.

2.2 Cover Dimensions

Several types of coal cars are used in the unit train service. Variations occur in length, width, height, shape, and material used. It would be expensive, confusing, impractical, and an operational nightmare to fit each coal car with a 'tailor made' cover. The coal car dimensions which affect cover design the most are the length and breadth of the top sill.

We would propose that a cover be designed that would fit all coal cars irrespective of size. This is to be achieved with minimal retrofitting, cost and weight penalty to the coal cars.

2.3 Cover Material

In the selection of cover materials the foremost considerations were:

- weight,
- strength,
- flexibility; rigidness,
- cost,
- ease of manufacture,
- resistance to impact and rough handling,
- ease of repair
- ease of handling,
- resistance to extremes of weather,
- resistance to corrosive materials,
- compatability with thaw shed operation.

Possible materials are:

- rubber,
- steel,
- aluminum,
- magnesium,
- fibreglass and other forms of rigid plastic,
- canvas,
- plastic film,
- spray on materials.

The materials satisfying the foremost considerations listed above are:

- aluminum,
- steel,
- fibreglass reinforced polyester,
- rubber,
- spray on materials.

Aluminum Covers

Aluminum covers meet weight, strength, and rigidness requirements. They would resist rough handling and extremes of weather. Galvanic corrosion is possible where the cover and car sill contact. Damaged covers would be difficult and costly to repair, requiring specialized skills and equipment. Each cover would weigh approximately 950 kg.

Steel Covers

Steel covers would be strong, rigid, and resist rough handling. They would be easy to handle and would be compatible with thaw shed operation. Extremes of weather will have little effect on the cover and the steel could be protected against corrosion by a suitable coating. Damaged covers would be difficult and costly to repair, requiring special skills, machinery, and handling equipment. Each cover would weigh approximately 2177 kg.

Fibreglass Covers

Fibreglass reinforced polyester covers meet weight, strength and rigidness requirements; they would resist rough handling, corrosive materials, and extremes of weather. Maintenance would be minimal and damaged covers would be easy and cheap to repair, requiring no specialized skills and equipment. Each cover would have an approximately weight of 1088 kg.

Reinforced Rubber Covers

Covers made from reinforced rubber would seem to satisfy many of the foremost requirements, and although time has not permitted investigating this material, it should not be discounted.

Spray on Materials

Spray on materials forming a crust on the coal, either in its existing form or improved versions must be considered a type of cover. As at this time spray on materials have not been 100% effective in controlling fugitive coal dust emissions.

2.4 Cover Type

Ideally, a cover would remain attached to the coal car at all times. It would stay on the coal car throughout loading and dumping operations, and would only be removed for repairs, major maintenance or replacement. There would be no need to modify coal cars to accept a universal cover, and complicated and costly handling systems would not be necessary. Unfortunately, the existing loading, unloading and car utilization systems do not permit an easy solution. Coal cars used in unit train service are not necessarily dedicated to that system and may from time to time be withdrawn for use by other producers. These producers will not have the equipment needed to handle permanently attached covers and so the covers will have to be removed for the duration they are out of unit train service.

Major problems would be encountered at the terminal where the direction of rotation of the dumpers vary. The Heyl & Patterson single rotary dumpers at Westshore and Neptune Terminals rotate counter-clockwise, while the Dravo-Wellman dumper at Thunder Bay and the Link Belt dumper at Pacific Bulk Terminals both rotate clockwise. The new Dravo-Wellman twin rotary dumpers to be installed at Westshore in 1983 and 1985 will be installed parallel and will rotate inwards (towards each other). One dumper will rotate counter-clockwise (1983 installation) and the other dumper will rotate clockwise (1985 installation). This would prevent the installation of covers that are attached to the coal cars and hinged on one side. The two dumper clamp bars which clamp the cars on the top sill about 10 feet from each end of the car, would interfere with the cover in those locations and restricted side clearances particularly at the platen side of the dumper adds further to the problems of using attached covers. Refer to drawings SK-015 and SK-016 in Appendix.

At the loadout stations, interference between opened cover and bin support structure would prevent the use of hinged covers of the 'hinged one side latched other side' type. This type of cover also prevents control room operator a view inside coal car when cover is hinged on the side of the car nearest the control room. Not all control rooms are located on the same side of the loadout, thereby further complicating the use of 'flip top' type covers. This type of cover also prevents the rotation of cars to ensure even wear on wheels. See SK-017 in Appendix.

Following are a number of cover types, their attachment to the coal car, and the limitations to their use.

- Concertina Style Folding Covers - folding towards the end of the cars (SK-008 and SK-009 Phase 1 Report in Appendix 'A')
  - Dumper clamp bars interfering with cover guide rail.
  - Severe icing would hamper opening/closing.
  - Each car must be fitted with motor to operate pulling mechanism, or alternately exterior drive has to be temporarily connected.
  - Probably insufficient clearance between cars for stacking cover sections.
  - Clearance between cars required so that there is no interference with indexer/positioner arm.

- Folding Covers - folding to the side of the car
  - Dumper clamp bars would interfere with covers.
  - Each car would have to be fitted with powering method to open and close cover.

- Clamshell Covers - hinged each side of car and opening from centre (SK 006 and SK007 Phase 1 Report)
  - Dumpers limit overhang of covers at side of car.
  - Dumper clamps interfere with covers.
  - Operator of loadout would have restricted visibility.

- Hinged One Side, Latched Other Side

  (SK004, SK005 Phase 1 Report)

  - Must always enter dumper in the same direction, which would forbid rotation of cars.
  - Must always enter loadout in the same direction to allow operator a good view of loadout chute.
  - Interference with clamp bars at dumper.
  - Dumpers limit overhang at side of cars.

  Some of these difficulties could be overcome in a system where new loadouts and new dumpers are to be constructed.

- Pivoted Cover - swinging down side of car
  (SK-010 Phase 1 Report)

  - Side clearance at dumper would not permit this style of cover.
  - Method of opening and closing cover is difficult

- One Piece Lift Off - remove, carry round, replace
  (SK-014 Phase 1 Report)

  - Expensive handling equipment required at both loadout and terminal.

- Three Section Lift Off
  (SK-012, SK-013 Phase 1 Report)

  - Lifting off while in dumper adds extra time to cycle.
  - Could not be adapted to loadout method.

- Swing Roof

A cover developed by the Stanray Corporation and known as the 'Stanray Swing® Roof' incorporates hinges on both sides and can be opened from either side by rotation in a rotary dumper. A drawing and description of the 'Stanray Swing®Roof' is shown in the Appendix. Limitations to the use of this cover are:

- Dumper clamp bar interference.
- Dumper platen would interfere with cover which could only be opened partially.
- Opening scrolls at loadout would have to cater for both right and left opening to enable operator clear view.
- Height of opened cover would interfere with loadout structure.

Some of these difficulties could be overcome in a system where new loadouts and new dumpers are to be constructed.

Existing Rail Car Cover Systems

Unit trains carrying lignite from the coal tipple at Gascoyne in southwestern North Dakota, to Big Stone Plant in northeastern North Dakota, have a cover that remains permanently on the coal car. It is known as the 'flip top' lid. The lids were fabricated and installed on new cars in 1975 by the Stanray Corporation, following design specifications developed by the Bechtel Corporation. Each car has five separate roof sections that can be automatically raised and lowered. The roof is raised when a steel roller attached to the roof contacts a 'scroll' pipe which is ground mounted. The 'scroll' is contoured to lift each lid of the car until it is vertical. Once the car has passed the loadout chute the 'scroll' lowers the lid back onto the car. A more detailed description of the 'Flip Top' lid is enclosed in the Appendix.

Other rail car covers at present in use in Canada and the United States are described in Section 8.0 of Phase 1 of this study.

Conclusion

- Covers that are removed prior to loadout and dumping, carried around the stations and then replaced on the coal cars, seems to be the most practical means of overcoming the many problems associated with permanently attached covers. It is the removable type of cover that we shall concentrate on during the remainder of this report.

2.5 Cover Shape

The shape of the coal car cover is determined by its size, the forces acting upon it, and suitability for use in the unit train system. The following aspects must be considered:

- its own weight while spanning car,
- aerodynamic uplift, downpressure causing flexing,
- weight of snow,
- wind forces while being transported by carrier system,
- clamping pressures: minimal bulging, bowing, deflection between clamps,
- high enough to clear highest level of coal at loadout facility,
- low enough so that when placed on highest car is still lower than loco or caboose,
- shaped such that they can be stacked when not being used,
- symmetrical so it can be placed with either end at the front,
- periphery shaped to minimize entrance of water and wind.

2.6 Cover Cost

The cost of covers is eventually reflected by increased port charges, increased freight charges, and would eventually be borne by the shipper-producer along with the costs of the handling systems. It is therefore most desirable that the covers be as inexpensive as possible, that they be cheap and easy to repair when damaged, and that they be designed and made from material that renders them as free of maintenance as possible.

In considering the cost of covers made from aluminum, steel and fibreglass, the following prices have recently been obtained from local manufacturers.

Aluminum

Although the weight of aluminum is only one third that of steel, the purchase price per pound is over five times more. A local fabricator has priced the manufacture of a cover made from 3/16" aluminum at approximately $8,190.00 This price does not include any protective finishing.

Steel

Despite being only one fifth the price of aluminum per pound, a steel coal car cover made from 10 gauge mild steel, formed and welded, would cost in the order of $7,500.00 each. To sandblast and apply a two part epoxy protective coat would add a further $1,700.00 to the cost of each cover.

Fibreglass Reinforced Polyester

A budget price has been obtained for the supply of fibreglass covers based on a quantity of 1000, with a high quality gelcoat pigmented finish, requiring no further re-finishing and no future attention. Price ±$3,600.00 each.

Reinforced Rubber Covers

As previously mentioned, rubber covers have not been investigated, and at this time no price has been obtained.

Spray on Materials

In a study prepared in 1980 entitled 'A Study of Coal Dust Contamination of Canadian Cellulose's Watson Island (Prince Rupert) Pulp Mill from the Operation of a Coal Terminal on Ridley Island and Coal Unit Train Access and Egress to the Proposed Terminal' - Phase II - Mitigating Measures, the authors adequately cover the costs of applying chemical binders to loaded coal cars. The cost of this type of cover is identified as 12 cents per ton of coal shipped (1980) based on the movement of five million tonnes of coal 1,125 km from two mines located in Northeastern British Columbia to the terminal at Prince Rupert.

2.7 Cost of Tooling for Covers

Aluminum Covers

Tooling requirements such as assembly and welding jigs, lifting and handling equipment will be of the type that all fabricators have in their workshops, and no special tools or equipment will be needed for the manufacture of aluminum covers.

Steel Covers

The fabrication of steel covers will be handled in the same manner as the fabrication of aluminum covers, and like aluminum covers, no special tooling will be required.

Fibreglass Reinforced Polyester Covers

Fibreglass covers are made by laying fibreglass reinforced polyester into a mould until 'set', at which time the cover can be removed from the mould and another cover laid in.

Moulds can be made of a variety of materials depending on quantity of parts required and quality of finish desired. To produce covers suitable for covering coal cars, a typical mould would be made of high temperature reinforced plastic. It would cost about $25,000.00 and would be good for moulding 100 covers, after which another mould would have to be made.

Moulds made from steel give a high quality product and have an indefinite life. To produce covers suitable for covering coal cars, a typical steel mould would cost in the order of $80,000.00.

The mould costs mentioned above are included only as general interest and are not additional to the price of covers mentioned in Section 2.6. The figure of $3,600.00 per cover includes about $250.00 to cover the mould costs.

2.8 Time Required to Manufacture

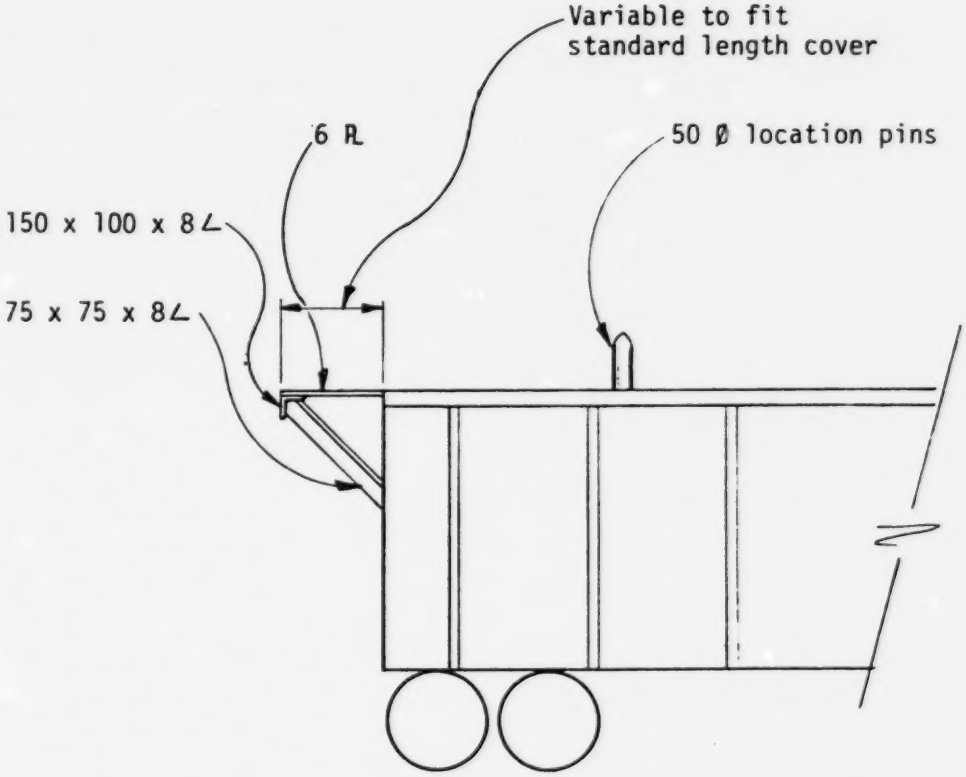
Two fibreglass product manufacturers of medium size have indicated that they could mould four covers a day in their present facility. This quantity could be doubled if necessary, by increasing staff and floor area. If coal cars could not be retrofitted at the same rate as covers were produced, then outdoor storage areas would have to be obtained.

Due to time consuming welding methods, steel and aluminum covers would take considerably longer to produce than would fibreglass covers. It is estimated that each steel or aluminum cover would take about 80 hours to manufacture.

2.9 Modifications Required to Coal Cars

Depending on the type of cover selected and the method of handling the covers at the loadout and at the terminal, some modifications may be necessary to the coal cars at present in service. New equipment being brought into unit train service would incorporate the changes at the manufacturing stage.

A conceptual retrofitting cost is shown in sketch numbers SK-018 and SK-019.



CONCEPTUAL RETROFITTING NECESSARY
FOR COAL CARS TO ACCEPT
REMOVABLE COVERS

(FOR CARS OF SHORTER BODY LENGTH)

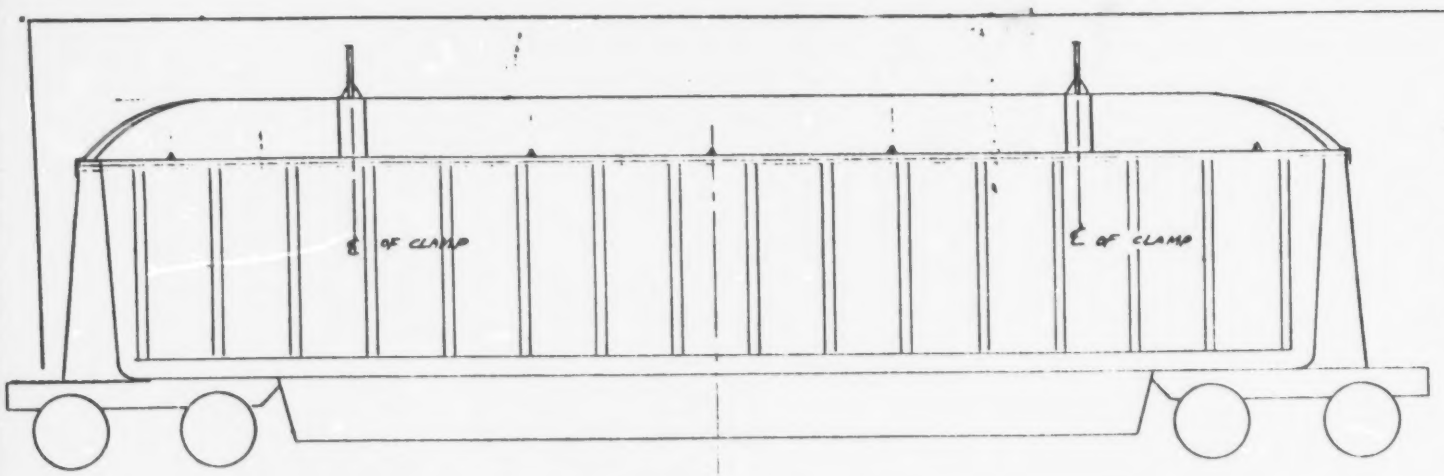
Assuming a price of $2.42/kg of steel (installed price) cost of modifying a typical car =

2 - 6 PL x 600 x 3380	@ 47.1 kg/m^2	= 191 kg @ $2.42/kg	=	$462.00
2 - ∠ 150 x 100 x 8 x 3380	@ 15.2 kg/m	= 103 kg @ $2.42/kg	=	$249.00
6 - ∠ 75 x 75 x 8 x 1000	@ 8.92 kg/m	= 53 kg @ $2.42/kg	=	$129.00
4 - 50 Ø x 500	@ 15.4 kg/m	= 31 kg @ $2.42/kg	=	$ 75.00
				$915.00

Add to this the cost of taking coal car out of service into workshops and delivering back into service say 400.00

TOTAL TO RETROFIT $1315.00

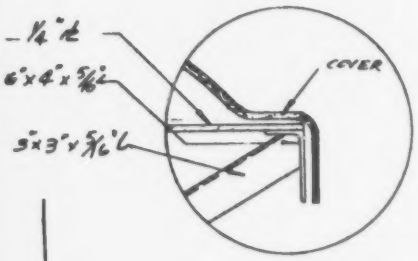
SK018



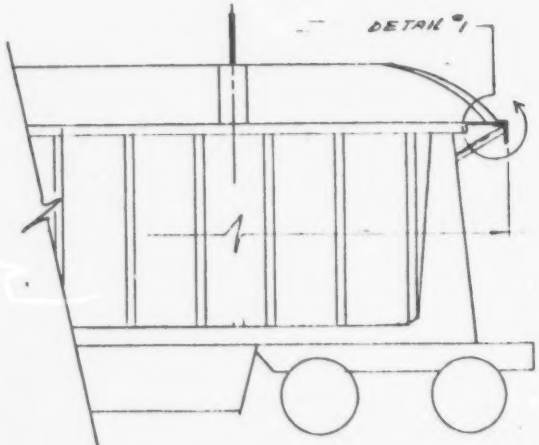
LONG BOX COAL CAR & COVER

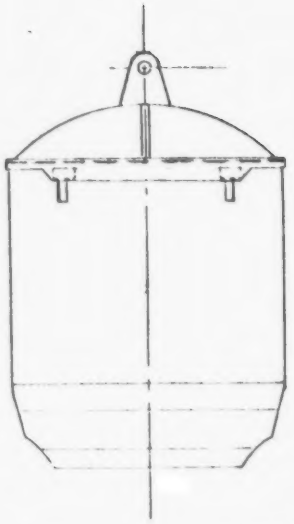
NOTE :- 1
. MODIFY COAL CARS SO THAT O/ALL LENGTH EQUALS THE LENGTH OF THE LONGEST COAL CAR IN UNIT TRAIN SERVICE THEREBY ELIMINATING THE NEED FOR VARIOUS LENGTH OF COVERS.

78



DETAIL " 1





SHORT BOX COAL CAR MODIFIED TO GIVE COMMON EFFECTIVE LENGTH

DWG NO JK 019

2.10 Effect of Thaw Shed Operation on Covers

Thaw sheds at Thunder Bay immediately precede the Strachan and Henshaw single rotary dumper. The thaw shed and dumper building is 600 feet long and contains six heated bays each wtih 24 Barber and Green propane fired infrared heaters delivering 280,000 BTU/hour each.

During winter the thaw sheds are used every day. The train enters the thaw shed and the first cars are left in the heated bays for 15 or 20 minutes to release the frozen coal from the sides of the cars. The cars are then indexed through the dumper at a 90 second cycle rate.

If covers were attached to the coal cars when in the thaw sheds, they would be subject to the high temperatures given by the heaters (in the order of 1,500^{o}F at source). As the temperature at the cover area is likely to be greater than 200^{o}F, fibreglass covers would have to be removed prior to the thawing operation.

2.11 Spontaneous Combustion

The spontaneous heating of coal in a pile is due to the action of oxygen in the air uniting with elements in the coal. The presence of moisture and sulphur in the form of pyrites, is believed to trigger the process. Since the rate of oxidation speeds up as temperatures go higher, the more heat absorbed by the coal the faster becomes the oxidation rate. These conditions must prevail for an appreciable length of time before the coal reaches the temperature of ignition and begins to smoulder.

A unit train leaving a mine in southeast British Columbia and going to a terminal in the Vancouver area would normally make the trip in 36 hours. Allowing for unscheduled stops and delays, the coal could conceivably be in the coal cars for 50 to 60 hours. This is not sufficient time for the coal in the cars to reach the temperature of ignition.

The presence of covers on the coal cars ensures that air cannot freely circulate and provide the oxygen necessary for oxidation, and without oxidation, ignition will not take place.

It is, therefore, safe to assume that when coal is transported in unit trains where the coal cars are equipped with covers, the chance of spontaneous combustion is negligible.

2.12 Summary and Selection of Most Promising Cover

To operate in the unit train system successfully, a coal car cover must satisfy the following conditions:

- One type of cover only, that would fit all unit train coal cars irrespective of their size and shape, and must be able to be rotated end for end.
- To be strong, yet as light as possible so that the forfeiture of coal in each car is minimal.
- To be able to withstand impact, rough handling, extremes of weather and corrosive materials.
- Must be inexpensive to procure and easily and cheaply repaired if damaged, requiring little skill and no expensive equipment.
- Must be compatible with automatic removal and replacement at loadout stations and terminals.
- Must be able to withstand high snow loads and wind speeds.
- Shaped to be stackable when not in use.

Table 2.1 compares the weight and cost of the three most promising alternatives.

TABLE 2.1

COMPARISON OF WEIGHT AND COST OF COVERS MADE FROM VARIOUS MATERIALS

COVER MATERIAL	WEIGHT	COST EACH	COST OF PROTECTIVE COATING	TOTAL COST EACH
Aluminum	950 kg	$8190	--	$8190
Steel	2176 kg	$7500	$1700	$9200
Fibreglass	1088 kg	$3600	--	$3600

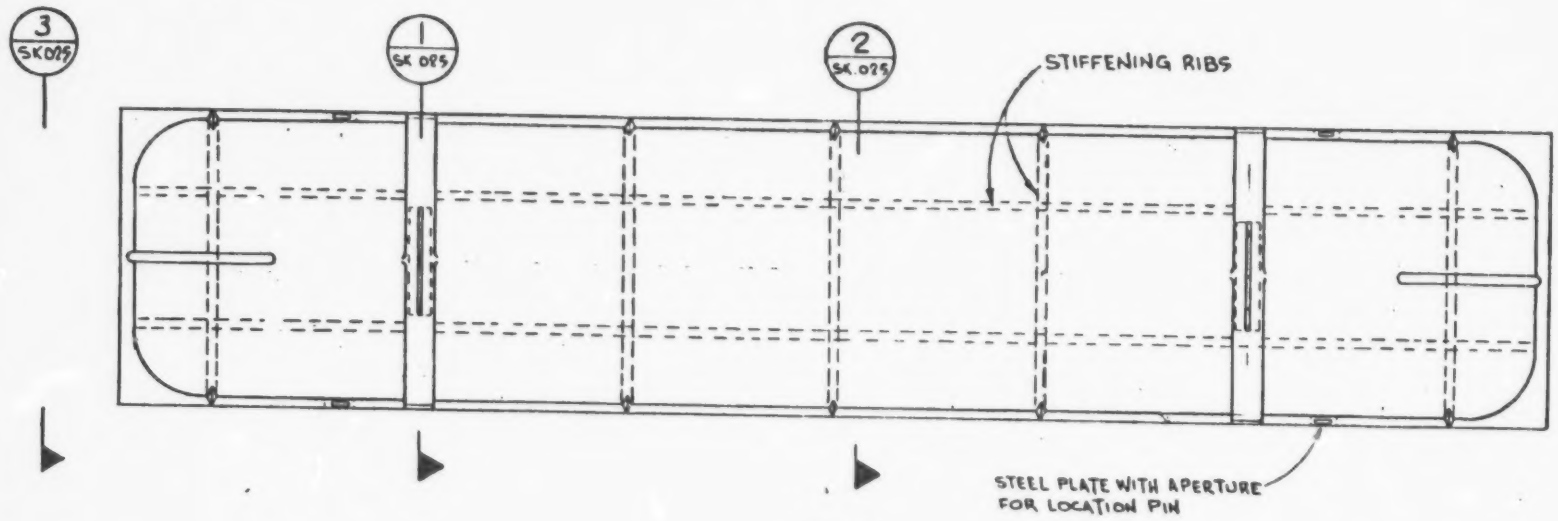
The weight of the covers requires that the car be loaded to less than design capacity in order that overloads are not present. The cost of this car underutilization is calculated in Section 3.7 of Phase III.

Because of the high cost of procurement, the weight penalty, the maintenance cost and the skill required to repair, steel covers are not now considered a promising alternative.

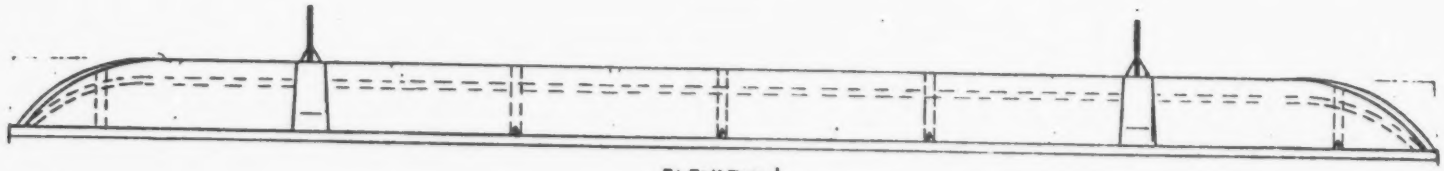
Although comparatively light, aluminum covers are costly to procure, difficult and expensive to repair, requiring specialized skills and equipment, and should be considered only as an alternative to fibreglass.

At $3,600.00 each, a weight of 1,088 kg and satisfying all the conditions mentioned in Section 2.11, fibreglass reinforced polyester covers must be considered the most promising alternative.

Although fibreglass covers have not been used in unit train service, they have been used extensively in other train service and have proved effective and economical. With an ultimate tensile strength of 1,260 kg/cm^2 to 1,406 kg/cm^2, and a shear strength across fibres of 914 kg/cm^2, they are strong enough to accept the loads and rough handling they may be subjected to in unit train service. Detailed structural analysis has not been undertaken at this time, but a fibreglass cover of the design shown in SK-020 and SK-021 would be similar to the final product.



PLAN



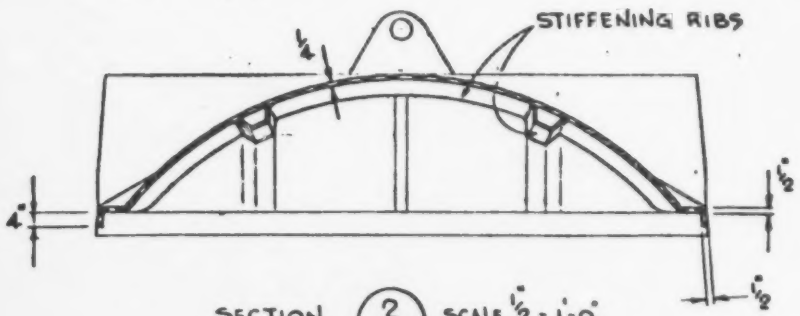
ELEVATION

COAL CAR COVER FOR AUTOMATED SYSTEM

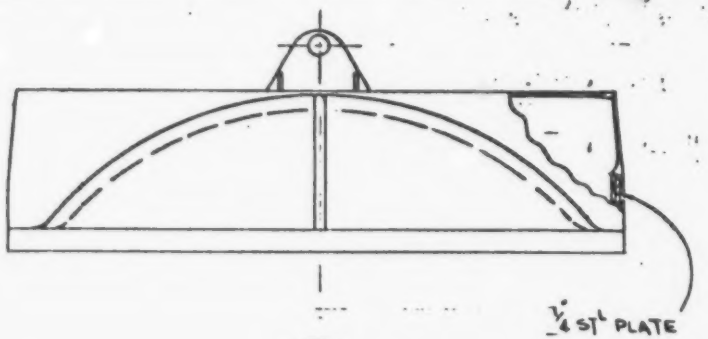
SCALE 1/4" = 1'-0

MAT'L. FIBREGLASS REINFORCED POLYESTER

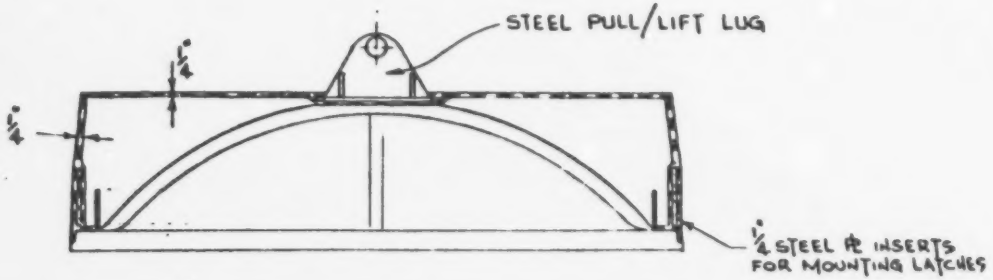
DWG. NO. SK 020



SECTION (2 / SK.024) SCALE ½" = 1'-0"



(3 / SK.024)



SECTION (1 / SK.024) SCALE ½" = 1'-0"

COAL CAR COVER FOR AUTOMATED SYSTEM

DWG. NO. SK. 021

3.0 PROPOSED COVER TO CAR CLAMP DESIGN

3.1 General

Coal car covers must be clamped or latched to the car to prevent them being lifted off by the effects of wind. The two types of wind affecting the cover are natural wind and wind created by a train in motion. (It has been reported that in the Prince Rupert area the strongest winds would probably exceed 100 mph). (Ref: 3 in Bibliography).

The clamps are to be strong, yet as light as possible, to be operated by mechanical means, but to be able to be operated manually for inspection and correction of weight load. It is imperative that the clamping/unclamping operation does not stop nor slow down the train. A common clamp is to be used on all covers and all coal cars.

The type of clamp selected for use on removable covers is a 'toggle latch' which will be attached to the cover. This type of latch allows a degree of flexibility in car sill depth, is positively locked in the closed position by the action of the toggle, and can be mounted vertically or horizontally with the release bar in a variety of positions to suit the type of handling system selected. Sprung pins applying pressure between the top sill of the car and the underside of the cover would provide a seal to prevent fugitive coal dusting.

3.2 Clamp Type

This section considers five types of cover securing methods, namely:

- Clamp
- Hinged Latch
- Magnetic Hold Down
- Toggle Latch
- Integral Latch/Cover

A wide variety of clamps can be designed. One type is illustrated in SK-022. Advantages of the type of clamp shown are - simplicity of design, relatively inexpensive, will be opened and closed by the same mechanism that lifts the cover from the coal car.

Although we have not been able to obtain the depth of the top peripheral tubular sill on all the cars in unit train service, it is assumed that there are variations to this dimension.

Unless the car sills were modified to make them effectively the same depth at the locations of the clamps, this type of clamp would not be very functional.

Hinged Latch

This type of securing method is not really a clamp as it does not apply pressure between cover and coal car. It will allow a certain vertical movement of the cover but would prevent 'lift off' of the cover. These types of latches are illustrated in drawings numbers SK-023, SK-024, SK-025. They allow a variation in the depth of the top sill of the coal car and can be manufactured with looser tolerances than pressure clamps.

Magnetic Hold Down

Magnets can be added to the cover that would hold the cover securely to the sill of the coal car. See SK-026. This method would be inexpensive, effective, and almost maintenance free. Unfortunately, the magnets would attract foreign metal objects, would have to be kept clean of coal dust, and would lose some of their holding force if iced over.

Toggle Latch

The toggle latches illustrated in drawings SK-027, SK-028, SK-029 allow flexibility in sill depth, are positively locked in the closed position by the action of the toggle, can be mounted vertically or horizontally with the release bar in a variety of positions.

This type of clamp is used extensively in the manufacturing industry and has proven itself strong and reliable in all working environments.

Integral Latch/Cover

An interesting latch that is built into a rubber or plastic cover is illustrated in SK-030. The spring steel strips that are moulded into the rubber cover make the integral latching edges positive enough to ensure good latching on coal car, yet are flexible enough to rotate free of the car sill, this being achieved by a 'hold down' on the arch of the cover while the latched edge is pulled upwards by the cover lift off mechanism, causing the edge to pivot and release from the sill.

3.3 Quantity and Location of Clamps

The number of clamps that are attached to each cover would be sufficient to overcome any chance of 'lift off' by natural wind and the wind created by the train in motion. Too many clamps could cause operational problems, increased chance of failure to open or close at loadout station and terminal, increased cost and maintenance, and a weight penalty in terms of payload.

Ideally there would be no more than four clamps on the car and it would be preferable if there were no clamps at the front or back, as this would limit the options of mechanical opening and closing.

If two clamps were located at each side of the coal car approximately 3 metres in from the ends, they would be effective as a hold down of the cover and be positioned suitable for mechanical opening and closing.

Because the outer sill of the coal car rests on the platen of the dumper when being rotated, it is imperative that there be no protrusion at the side sills. Therefore, any clamp or latch must be attached to the cover, which will be removed prior to entering the dumper.

3.4 Clamp Mounting

To ensure clamps can be easily removed in the event of failure, or if replacement is required, they should be bolted or screwed to the cover.

3.5 Clamp Weight/Material

The clamp could be made from:

- carbon steel,
- stainless steel,
- aluminum,
- brass,
- plastic.

Carbon steel clamps would be preferable over clamps made from the other materials. They would be stronger, less expnesive, easier to repair or replace if damaged, and more able to withstand rugged handling.

The combined weight of four clamps, no matter from which material they were made, would not be excessive and the other considerations would be paramount.

3.6 Clamp Maintenance

It is imperative that the clamp selected be designed such that it is as maintenance free as possible. Any form of maintenance programme would be very costly and complicated, and would add additional cost to the coal.

3.7 Clamp Cost

The toggle latch-hinged latch and the clamp shown in drawings SK-022, SK-023, SK-024, SK-025, SK-027, SK-028, and SK-029 would cost within the range $100.00 to $200.00 each.

A continuous bar magnet (see SK-026) down each side of the cover, purchased in large quantities would cost approximately $2.00 per foot or in the order of $210.00 for each cover.

Individual permanent magnets 5" square would cost in the order of $200.00 each, or $3,200.00 per cover.

3.8 Protecting Clamps from Icing

Due to the exposed position of the cover clamps, they will be subjected to severe wet and sub-freezing conditions. It is possible when a train reaches the loadout station or terminal, that there could be a buildup of ice around the clamps. This may cause difficulty to the opening operation and it may be necessary to apply a freeze release agent to the clamps.

3.9 Summary and Selection of the Most Promising Latch

The latch selected will prevent the cover being lifted off by the effects of strong winds. It will be robust enough to be operated by mechanical means and also be able to be opened and closed manually. It will be simple to replace and require minimum maintenance. One type of clamp latch will be used on all covers and will operate unattended. It will allow flexibility in the size of the top sill of the coal cars and will not stop nor slow down the train during opening and closing operations.

The latch type selected that will satisfy these requirements is the 'toggle latch'. Latches of this type are illustrated on drawings SK-028, SK-029, and SK-031 in Appendix.

The opening and closing method is dependent on the type of handling system installed. Shown on SK-031 is a concept of a lifting/carrying arm. This type of latch and lifting arm would be compatible with a handling system such as the power and free conveyor described in Section 4 of this report.

It is the toggle latch SK-031 that we recommend as the most promising. Four latches of this type installed on each cover would weigh approximately 50 kg and the cost in the order of $300.00 each.

3.10 Fail-Safe Characteristics

The toggle latch selected obtains its fail-safe characteristics when its lever arms move past their mechanical center in the locked position. Once locked, only destruction of the latch or direct force on the opening handle, would cause the latch to release. Closing of the latches must be confirmed automatically or visually when the lids are placed on the cars.

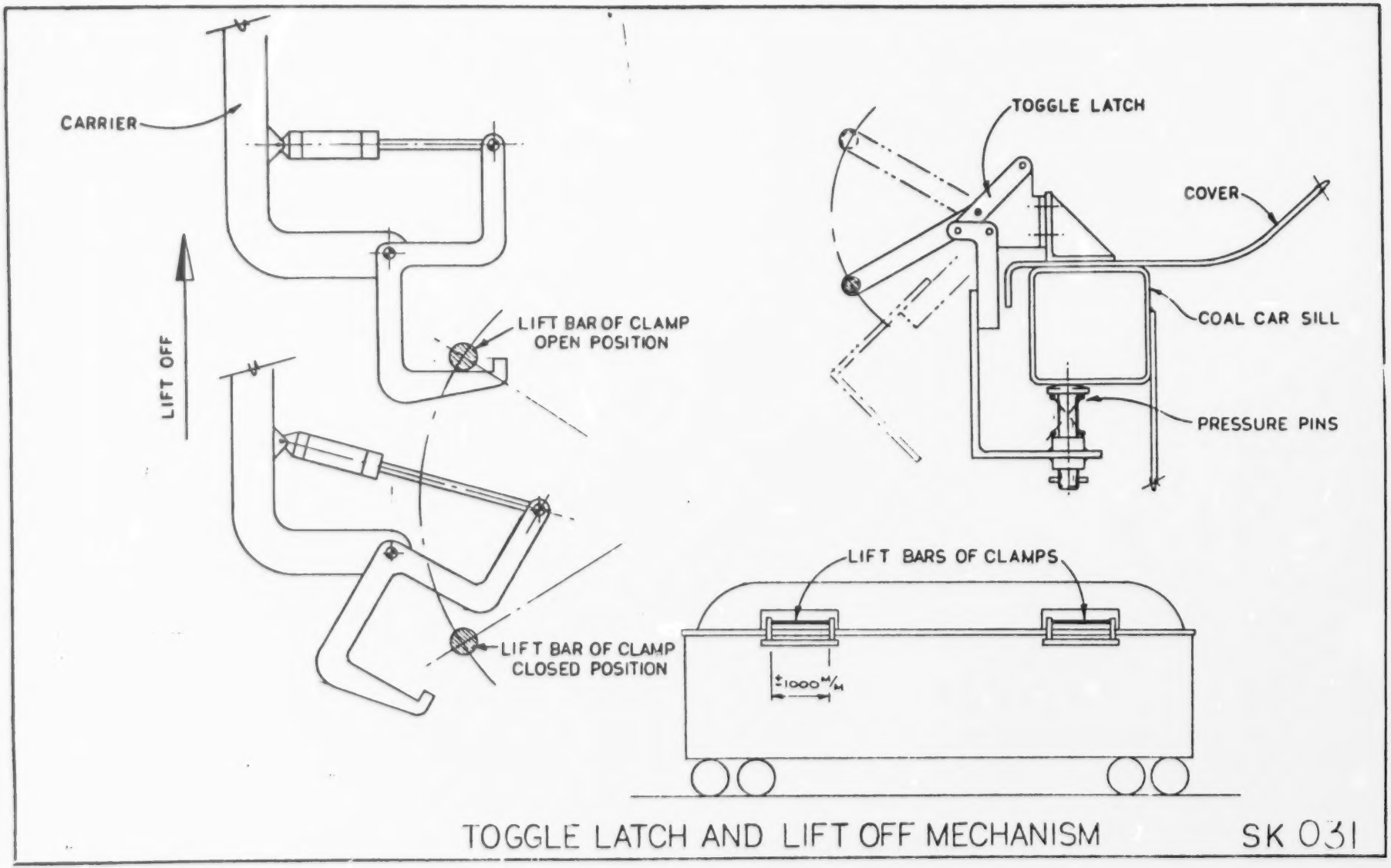
3.11 Effects of a Cover Failure During Train Journey

If the fibreglass cover system on a coal car failed completely whilst the train was travelling at maximum speed, the damage that could occur to the

locomotives, robot, and caboose if the cover were to be thrown into them would be local and minimal. The chance of a released cover damaging a coal car is highly improbable and the chance of a derailment almost zero. However, if such a failure did occur, and a cover were to be lifted from the car and blown into properties in the neighbourhood of the rail line, the damage could be much more severe. At 1088 kg, a fibreglass cover weighs as much as a very small car, albeit much more fragile, and could cause a fatality to anyone unfortunate enough to be in its path. If the cover were to collide with property in the area, the damage would probably not be major, say in the order of $300,000/occurrence.

If a five piece steel hinged cover was to fail, it is possible that all five segments could be ripped from the car in a chain reaction. Five segments weighing in the order of 440 kg each have the potential of causing considerably more damage to property than a one piece fibreglass cover.

In all cases of death, injury, or damage, the railways would assume liability.



TOGGLE LATCH AND LIFT OFF MECHANISM SK 031

4.0 PROPOSED COVER HANDLING SYSTEM

4.1 Clamp Release/Close Mechanism

It is imperative that the clamp release and clamp close mechanisms operate such, that the train will not have to be stopped nor slowed down during these operations. The mechanism must allow for train speeds of up to 1.6 km/hr with surging, and must position precisely. It will allow for coal cars of varying height and will clear locos and caboose.

4.2 Removal and Replacement of Damaged Covers

Damaged covers must be recognized, removed from the system, and a good cover inserted in its place. This is to be accomplished so that the train will not have to be stopped nor slowed down. The equipment needed to remove the damaged cover and replace it with a good cover, would preferably be an integral part of the lift off and carrying system. It would require no additional equipment and no additional operating personnel.

4.3 Cover Jamming

The chance of a cover jamming so that it cannot be removed from the coal car by the handling system would be a rare occurrence. In all such cases, we can assume the jamming is caused by a malfunction of the latching mechanism which would require a maintenance crew to rectify. If 25 such incidents occur each year at either the loadout station or the terminal on a given route, the time require to unjam the covers may be as follows:

- Twenty incidents - ten minutes to rectify
- Three incidents - one hour to rectify
- One incident - two hours to rectify
- One incident - four hours to rectify

With a maintenance crew of two, this time would amount to 25 hours/year. In nearly all cases of jamming, the train will have to be stopped for the maintenance crew to effect the release of the cover, thereby adding to the turn around time of the train.

4.4 Cover Storage Facilities at Loadout and Terminal

An area must be set aside at both the loadout stations and the terminals where covers can be stored. The storage area need be an open area about 460 m^2. In this area would be stored damaged covers that have been removed from the coal cars and are either awaiting repairs or awaiting disposal, if too damaged to be repaired. Stored in the same area would be new or repaired covers that would be used to replace the removed damaged covers.

4.5 Cover Repair Facilities

Facilities must be obtained where damaged covers can be repaired and subsequently brought back into service. This can be achieved by the following methods:

- Use existing facilities at each mine and terminal if they are available.
- Expand existing facilities at each mine and terminal to accommodate a repair facility.
- Build a new repair facility at each mine and terminal.
- Transport damaged covers to a central repair depot serving a number of mines and terminals.
- Send damaged covers to a local fibreglass producer and have them repaired.
- Or a combination of several of the above, to suit local circumstances.

4.6 Removing Coal Build Up on Car Sill

Due to the method of loading and unloading, a residue of coal is sometimes left on the top sill of the car. It is necessary to remove this coal before the cover is replaced, in order to effect contact between the cover and the sill thereby making a better seal. This would be done immediately after each car is loaded at the mine and immediately after each car is uprighted after dumping at the terminal. The sill would be cleaned by a rotary brush system which would be located both sides of the track. As the locomotives pass the brushes they would be raised to clear, and as the first coal car approaches the brushes they would be lowered and started rotating, thereby sweeping the residual coal into the car and cleaning the sill. During the winter months if it was found necessary, a thin film of release agent which would disrupt ice crystallization could be applied to the car sill.

4.7 Cover Sealing

Because the cover perimeter hangs vertically over the coal car sill and the underside of the cover perimeter ledge site directly on the top of the sill, there is little chance of natural wind or wind created by the train in motion infiltrating the cavity beneath the cover with sufficient velocity to pick up coal dust. For example, if there was a 3/32" gap all around the interface of the car sill and the cover ledge, and there was the equivalent of a 50 mph wind on the front of the car, we have calculated that the air velocity beneath the cover would be in the order of 6 feet/minute, which is very low and not enough to cause coal dust to be picked up. We therefore feel that the cover proposed in Section 2.11 has sufficient sealing qualities, without the addition of sealing materials to prevent coal dust emissions.

4.8 Effects of Snow and Ice on Cover Removal

Snow and ice built up between the cover periphery and the car sill does not seem to be a cause for concern. Experience at Vancouver Wharves where copper concentrate from Lornex, Gibraltar, Anaconda, and from Pine Point in the Northwest Territories is received in cars covered with fibreglass covers similar to those proposed in this study (plates 2,3,4,5, Phase III Appendix) has demonstrated that icing and sticking of the cover to the car sill has never been known to interfere with the removal of the cover. This may be due to the low water absorbency of fibreglass, < 0.3%, and the property of fibreglass to resist wetting of the surface.

4.9 Manpower Requirements to Operate and Maintain a Cover Handling System at Loadout and Terminal

The installation of a cover handling system at the loadouts and terminals would require additional manpower to operate and maintain it. The additional manpower would incur costs that are eventually reflected by increased port charges, increased freight charges, and would eventually be borne by the shipper-producer along with the costs of the covers. It is, therefore, imperative that a system be designed that requires minimal manpower to operate and is as maintenance free as possible. One such system and the system that we recommend is detailed following.

4.10 Selection of the Most Promising Handling System to be Installed at Loadouts and Terminals

Using a system of power and free conveyors and automatically controlled power lift stations similar to the type manufactured by the FMC Corporation, coal car covers can be removed from the cars, taken around the loadout or dumper and placed back on the cars. The system is versatile and offers unlimited flexibility that could be used at all loadout stations and terminal facilities. The system combines

a powered trolley conveyor and an unpowered monorail-type free conveyor. Two sets of tracks are used, suspended one above the other. The upper track is structural I-beam and carries the powered trolley conveyor. The lower or free track consists of two structural channels or angles and carries four wheel load trolleys from which carriers are suspended. Load trolleys have two integral pivoted dogs which engage pushers attached to the power conveyor trolleys or chain. See Figure SK-032.

Powered lift stations consist of sections of free track , load trolleys, and carriers. These are moved vertically with a powered lift system which can be pneumatically, hydraulically, or electrically operated, and can be controlled manually or automatically.

The system we propose would operate in the following manner:

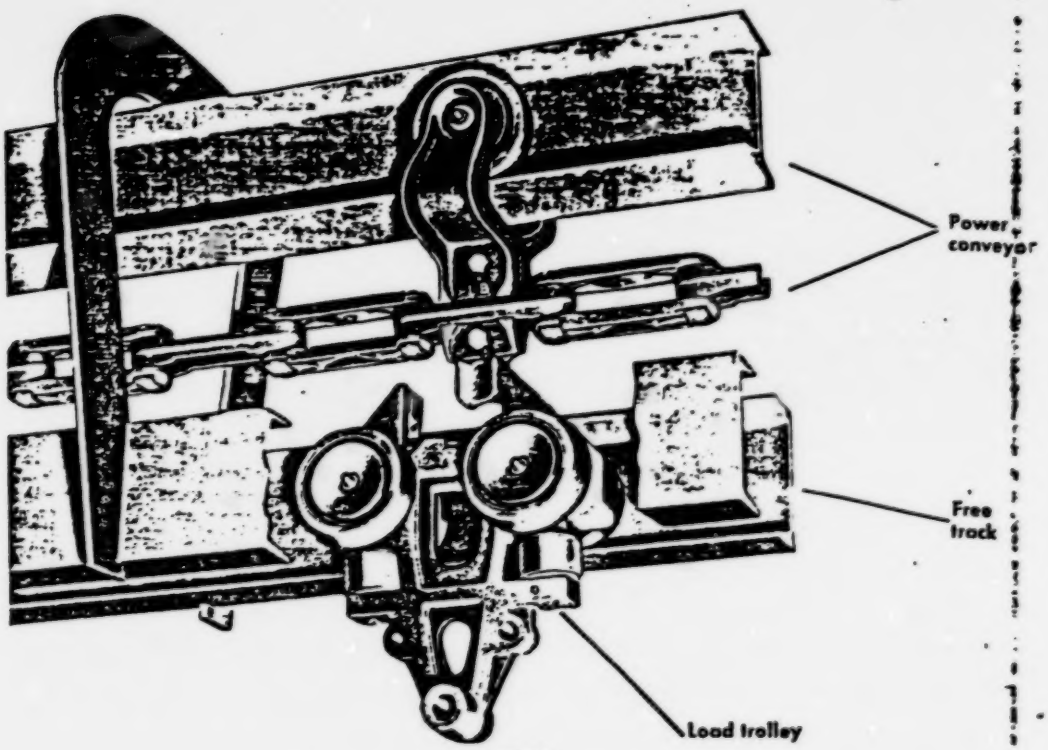
A powered lift station lifts the cover from the coal car by a carrier with an outrigger attached. When it reaches the height of the stationary free track ($\pm$ 24'-0" above top of rail) a powered conveyor 90^{o} opposed to the direction of train travel pushes a second carrier into the free track of the lift station. As the second carrier enters the lift station, an outrigger on the leading edge pushed the rear of the preceding carrier thereby pushing the carrier and cover out of the lift station. The second carrier and free track now descend, pick up a cover and raise it to the level of the stationary free track. A third carrier is pushed into the lift station by the powered conveyor pusher dogs. It pushes the second carrier and cover out of the lift station which in turn pushes the first carrier and cover along the free track. the first carrier and cover are pushed in this manner until they reach turn station #1 located a sufficient distance to clear the extremity of the loadout station or dumper building. The free track then ends and another free track 90^{o} opposed and parallel to the direction of train travel begins. A second powered conveyor running parallel to the train tracks and in line with the free track pushes the first

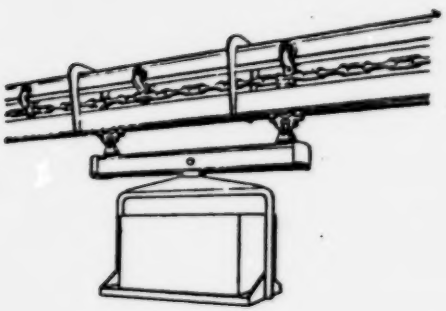
cover along the second free track a distance of one cover length. The second cover now enters this turn station and is subsequently pushed along the free track by the powered conveyor and it in turn pushes the first conveyor along. This procedure continues, forming a continuous line of covers each being pushed by the cover behind. Once the covers have reached the end of the loadout station or dumper building, turn station #2 turns them 90^{0} and they are pushed towards and into a lift station located above the rail lines.

To place a cover on a coal car, the powered lift would hold a cover just a short distance above the coal car and when the coal car gets immediately beneath the cover, a photo cell signals the equipment to lower the cover onto the car. Damaged covers would be seen by an operator stationed at the cover removal end of the system. The operator directs the damaged cover to a powered lift station where they are lowered and subsequently removed. To redirect the damaged cover entails stopping the powered conveyor at turn station #1 and entering a replacement cover. A typical terminal handling system is shown on SK-033.

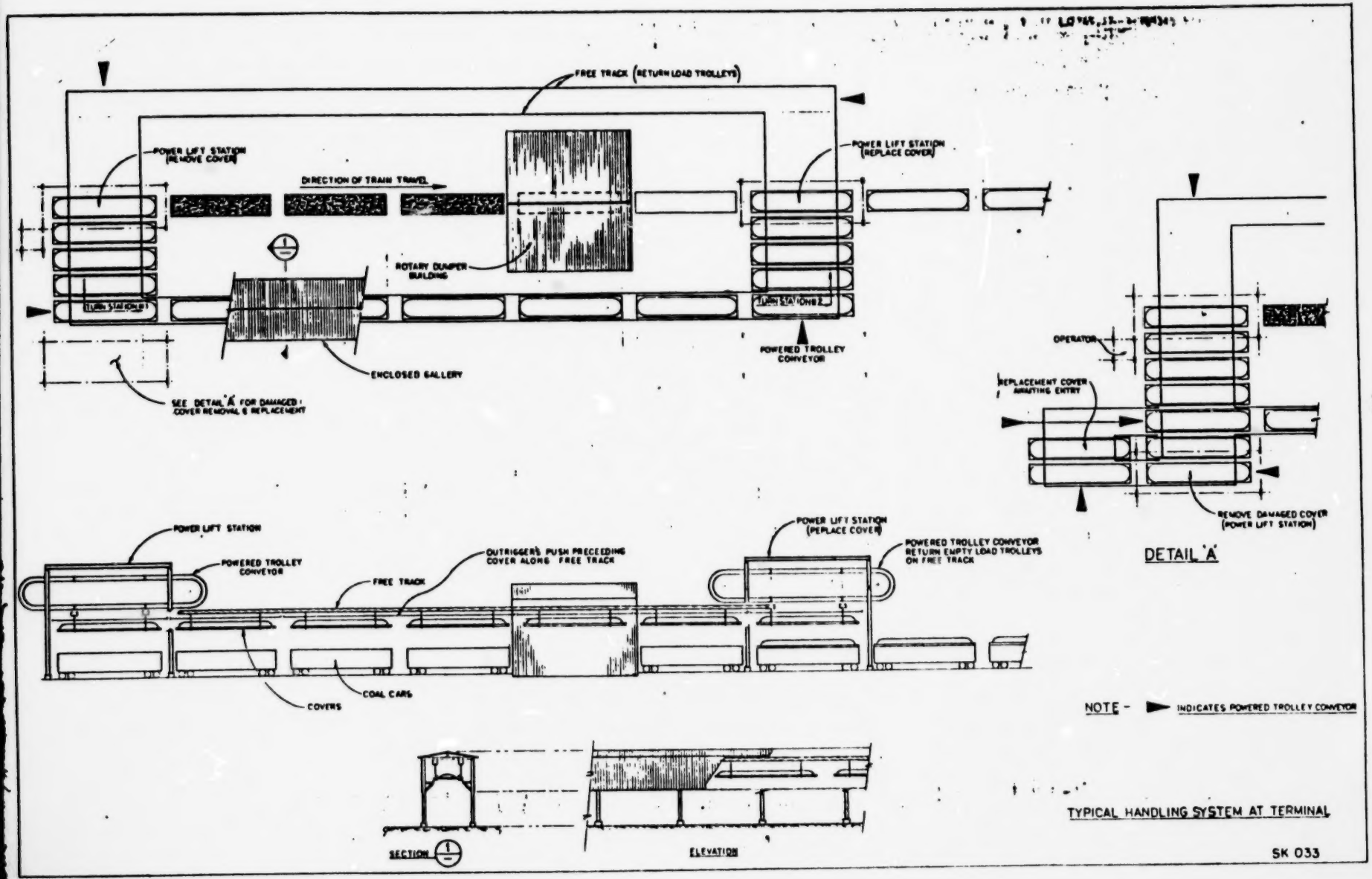
4.11 Strachan & Henshaw Handling System

The cover handling system described above differs greatly from the Strachan & Henshaw system studied by British Columbia Rail in 1977. Whereas the system described above removes the cover prior to the coal car entering the loadout or dumping station, carries it around and replaces it on the car after it has left the station, the Strachan & Henshaw system picks the cover off the car with an hydraulic arm whilst it is located in the dumper and replaces it when unloading is complete. (Refer Phase I, Section 8.8).





power and free conveyors


FREE TRACK (RETURN LOAD TROLLEYS)
POWER LIFT STATION (REMOVE COVER)
DIRECTION OF TRAIN TRAVEL
POWER LIFT STATION (REPLACE COVER)
ROTARY DUMPER BUILDING
TURN STATION 1
TURN STATION 2
POWERED TROLLEY CONVEYOR
ENCLOSED GALLERY
SEE DETAIL 'A' FOR DAMAGED COVER REMOVAL & REPLACEMENT
OPERATOR
REPLACEMENT COVER AWAITING ENTRY
REMOVE DAMAGED COVER (POWER LIFT STATION)
DETAIL 'A'
POWER LIFT STATION
POWERED TROLLEY CONVEYOR
FREE TRACK
OUTRIGGERS PUSH PRECEEDING COVER ALONG FREE TRACK
POWER LIFT STATION (REPLACE COVER)
POWERED TROLLEY CONVEYOR RETURN EMPTY LOAD TROLLEYS ON FREE TRACK
COVERS
COAL CARS
NOTE - INDICATES POWERED TROLLEY CONVEYOR
SECTION
ELEVATION
TYPICAL HANDLING SYSTEM AT TERMINAL
SK 033

4.12 Cost of Installing a Power and Free Conveyor System

To fabricate and install an FMC power and free conveyor system similar to that described in Section 4.6 and illustrated on SK-033 would entail the following costs:

- 350 metres of free track including six powered conveyors @ $1,625.00/m	$ 568,750.00
- Three lift stations @ $50,000.00 each	150,000.00
- 350 metres of support structure with cladding only in area where covers are routed @ $1286.00/m	450,000.00
Total cost of system	$1,168,750.00

The above cost estimate is for a hypothetical case. The totals would vary at each terminal and loadout, depending on the total distance the cover is routed around the loadout or terminal. If the empty trolleys at the cover replacement area could be raised another few feet by the power lift station, they may be able to return to the start of the system by following a route directly above the outward bound covers. In this manner the same structure, slightly modified, could be used for outward and returning load trolleys, thereby saving about $150,000.00 on the cost of the total system.

4.13 Manpower Requirements to Operate and Maintain a Power and Free Conveyor System

To operate the power and free conveyor system proposed in Section 4.6 and illustrated in SK-033, would require one full-time operator at the cover removal end of the system. The operator would oversee the removal of covers from the coal cars, and monitor through a closed circuit televison the replacement of covers at the other end of the system. The operator would also recognize damaged covers, re-route them out of the system, and at the same time insert into the system new replacement covers. Maintenance of the system would be minimal as would repairs. Existing maintenance crews would probably be able to handle the system with an extra 20 manhours per week.

5.0 SCHEDULE OF CONSTRUCTION OF COVER SYSTEMS

5.1 System No. 1 (Existing)

Fibreglass Lift-Off Covers

This type of cover could be made at the rate of four a day without straining the resources of the average fibreglass manufacturer. Installation of the covers onto the coal cars could be accomplished at the same rate.

To equip the approximately 3000 coal cars in the present unit train system with the fibreglass covers would, therefore, take in the order of three years.

The cover handling system could be engineered and constructed in 18 months.

Steel Hinged Covers

The five section steel hinged covers could be made at the rate of three a day and installed on the coal cars at the same rate. It would take nearly four years to equip the 3000 coal cars in the existing unit train system.

To engineer and modify existing loadout or silo and to manufacture and install the cover opening/closing scroll could be accomplished in 12 months.

5.2 System No. 2 (Greenfield)

Fibreglass Lift-Off Covers

This type of cover could be made at the rate mentioned in Section 5.1, i.e. four covers a day. Installation of the covers onto the coal cars would be dependent on and equal to the rate of manufacture of the new coal cars.

The cover handling system could be engineered and constructed in about the same time it would take to design and construct a new loadout and a new unloading facility - approximately 18 months.

Steel Hinged Covers

Steel hinged covers could be made at the rate of three a day. Installation of the covers onto the coal cars would be dependent on and equal to the rate of manufacture of the new coal cars.

To detail, construct, and install the cover opening/closing scroll could be accomplished in approximately 12 months, which would be within the 18 months necessary to construct new loading and unloading facilities.

APPENDIX

BIBLIOGRAPHY

Reference

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2. In-Transit Control of Coal Dust from Unit Trains, EPS, Guarnaschelli, C. Report Number EPS 4-PR-77-1, May, 1977.

3. A Study of Coal Dust Contamination of Canadian Cellulose's Watson Island (Prince Rupert) Pulp Mill from the Operation of a Coal Terminal on Ridley Island and Coal Unit Train Access and Egress to the Proposed Terminal.

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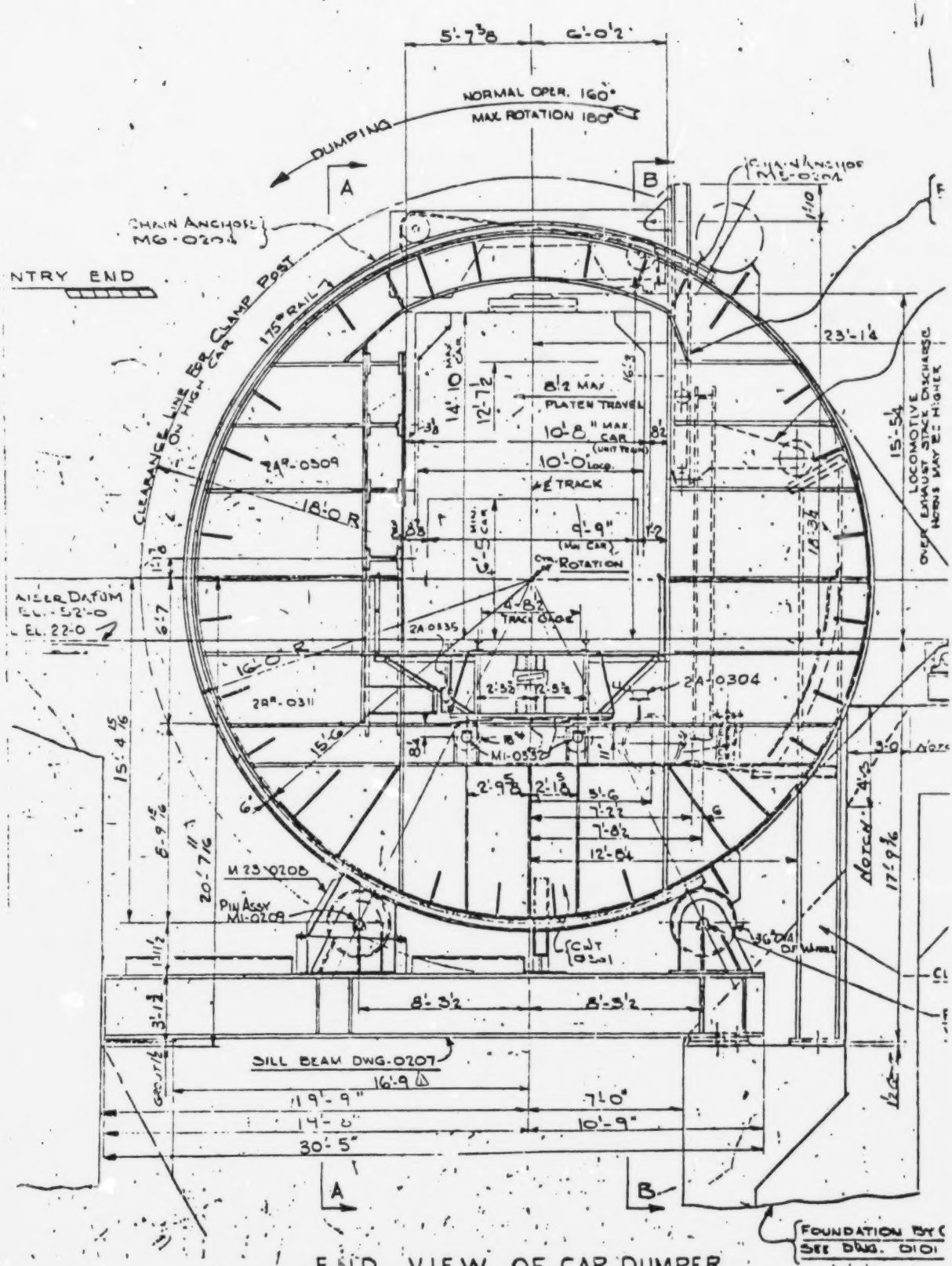
   Phase Two - Mitigating Measures, for Government of Canada, Government of British Columbia, by Beak Consultants Ltd., Hardy Associates (1978) Ltd., Sandwell and Company Ltd., Swan Wooster Engineering Co. Ltd., September, 1980.

4. Measurement of Crust Remaining on the Surface of Coal Cars on Arrival at Dumping Terminals, Results of Monitoring 30 Trains, Levelton, B.H., et al., #75-408E, October, 1975.

5. Trip Report: Fugutive Coal Dust Emissions from Coal in Railroad Cars, Observations from Western Canada, March, 1980, by D. L. Cope, July, 1980.

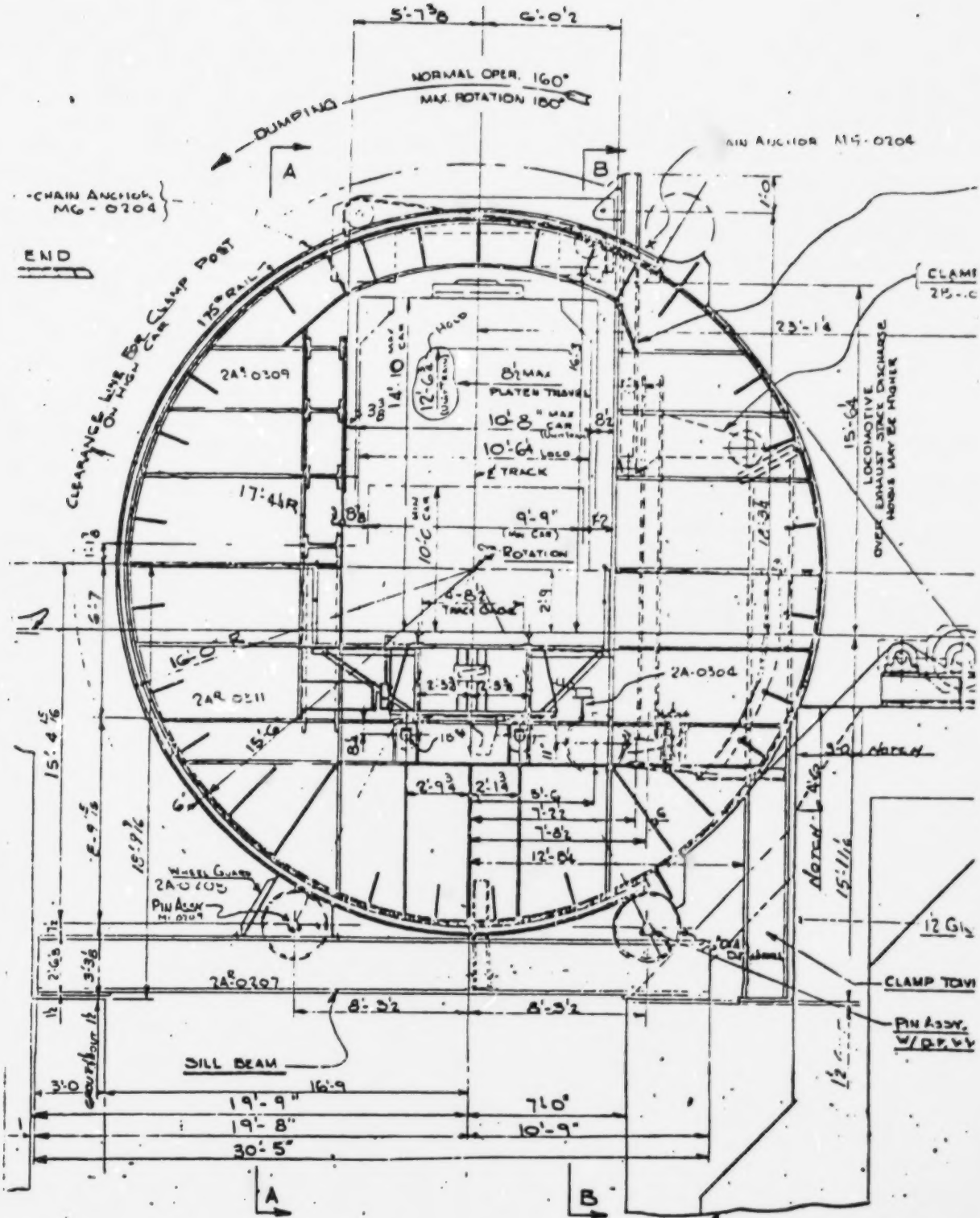
6. Coal Dust Control on Unit Trains, for Department of the Environment, Environmental Protection Service, September, 1975.



END VIEW OF CAR DUMPER.

WESTSHORE TERMINALS - ROBERTS BANK

SK 015

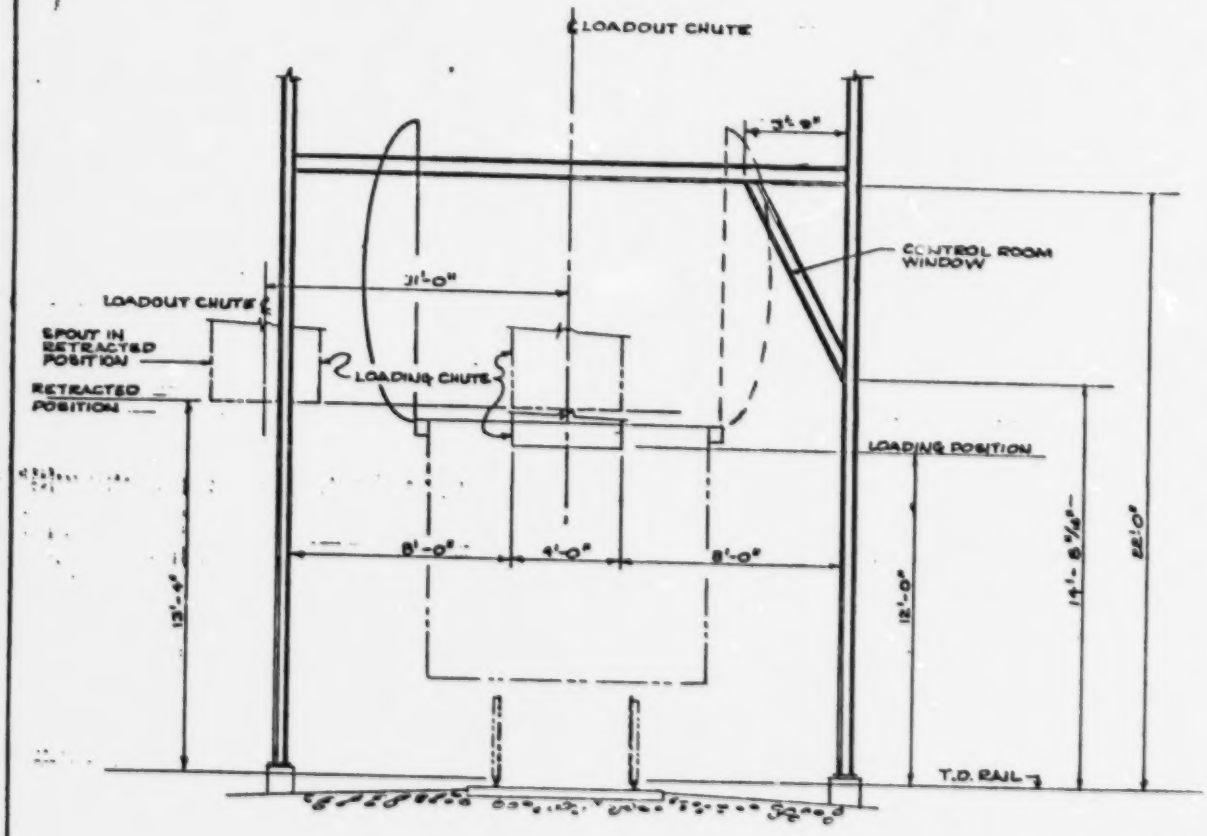


NEPTUNE BULK TERMINALS, N'VANCOUVER

END VIEW OF CAR DUMPER

EAST ELEV. LOOKING WEST

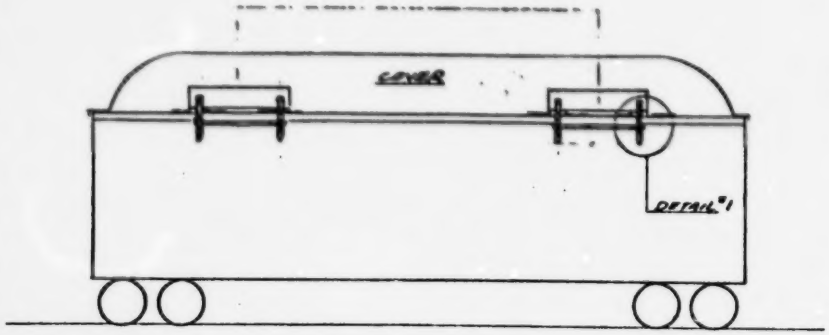
SK 016

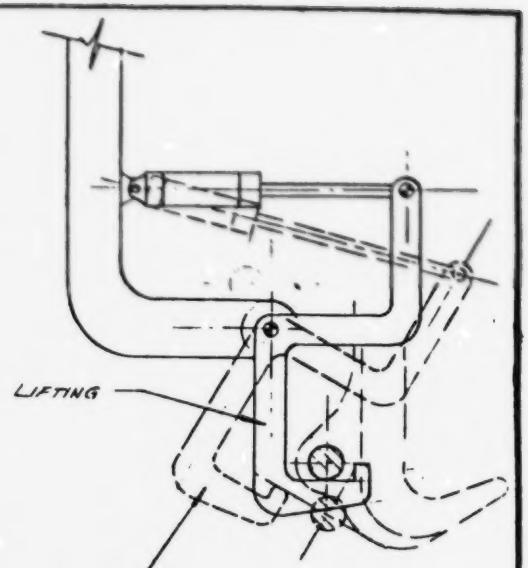


CLEAN COAL LOADOUT
SECTION AA
1/4"=1'-0"

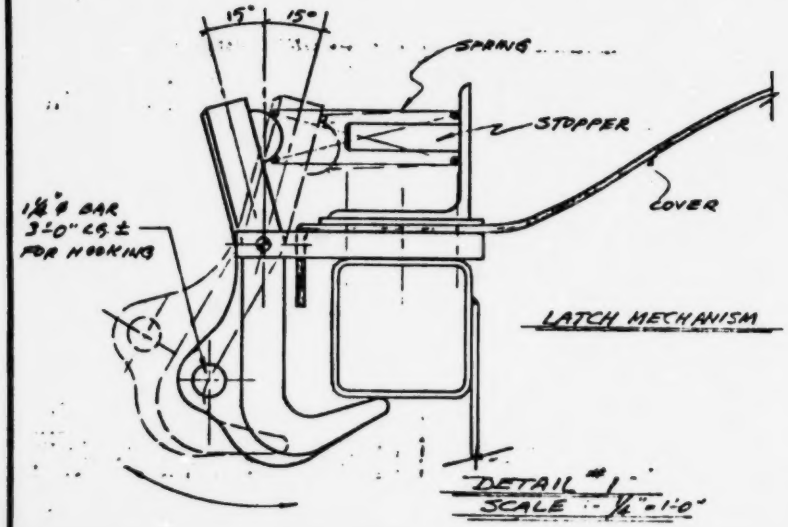
MINE-LUSCAR STERCO-COAL VALLEY
DATE-DEC.13.1981
INFORMATION SUPPLIED BY-R.STRONG
(403) 794-3700

SK.017





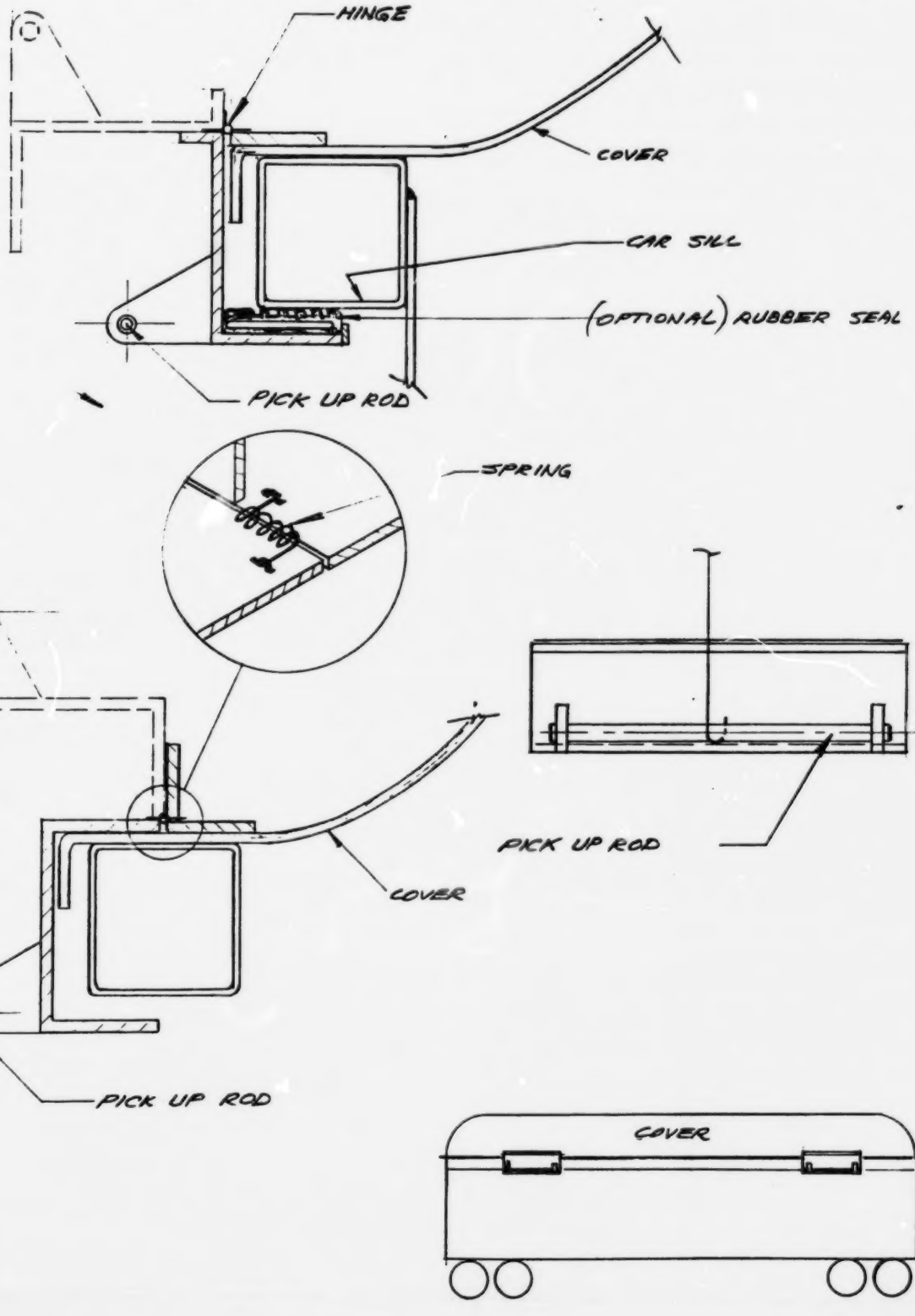
LIFTING MECHANISM



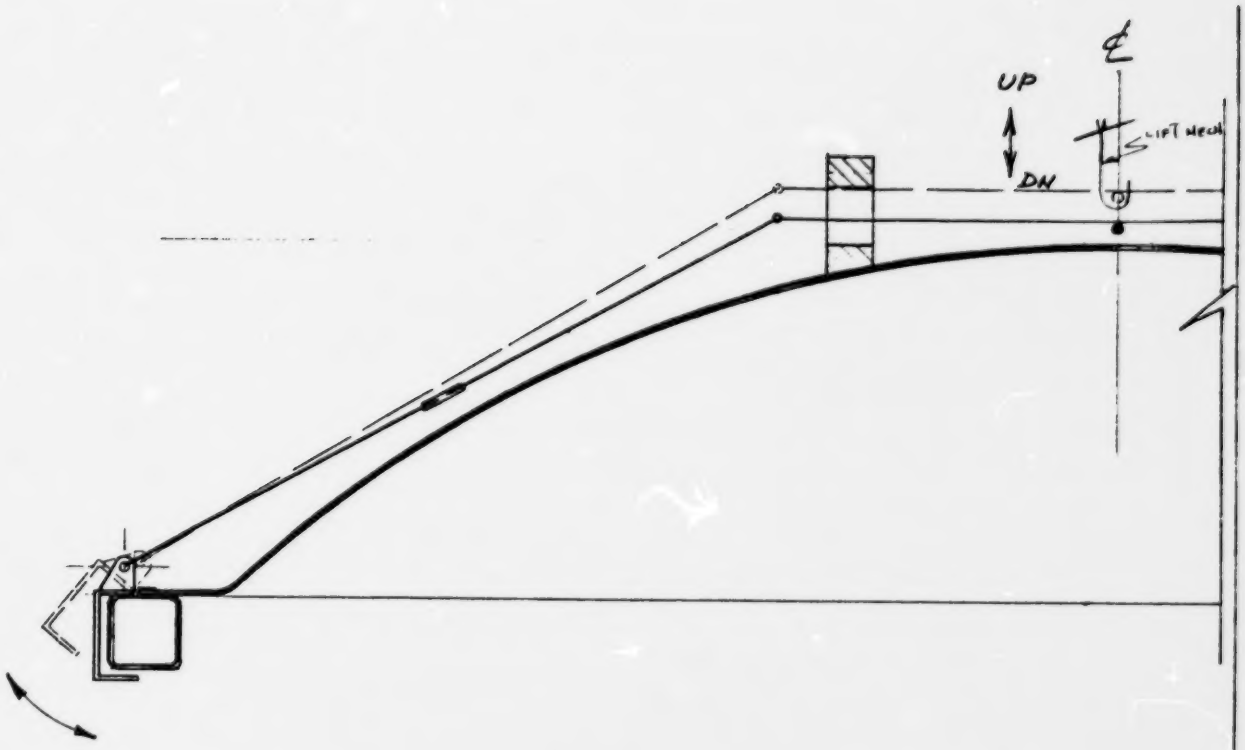
LATCH MECHANISM

DETAIL "1"
SCALE :: ½" = 1'-0"

DWG NO. SK-022
COAL CAR COVER WITH SPRING CLAMP

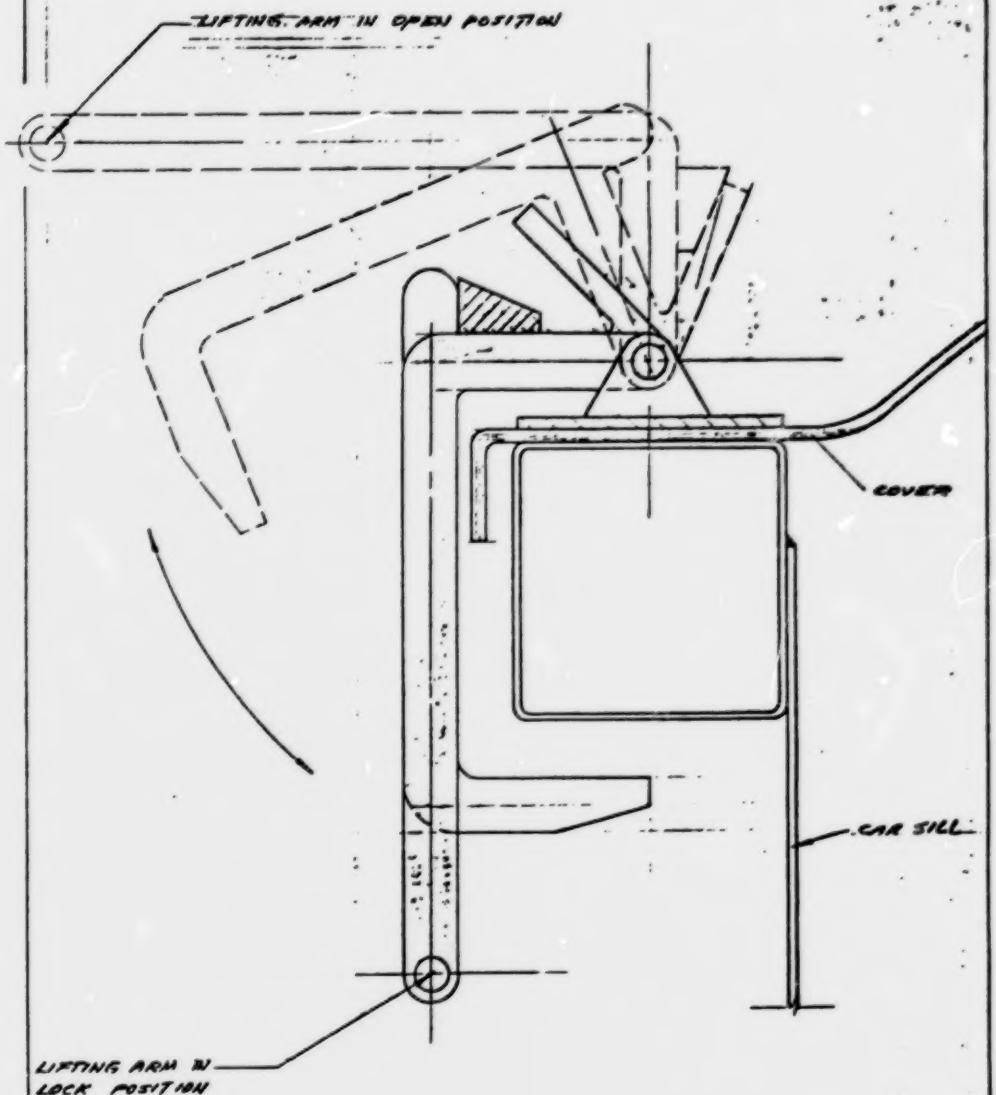

HINGE
COVER
CAR SILL
(OPTIONAL) RUBBER SEAL
PICK UP ROD
SPRING
PICK UP ROD
COVER
PICK UP ROD
COVER

DWG. NO. SK-023



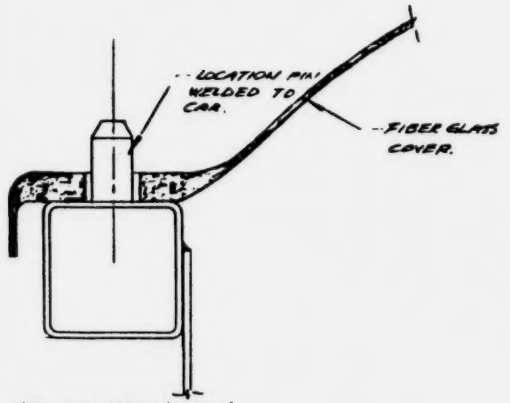
DWG. NO. SK-024

COVER WITH CENTRE PULL LATCH.

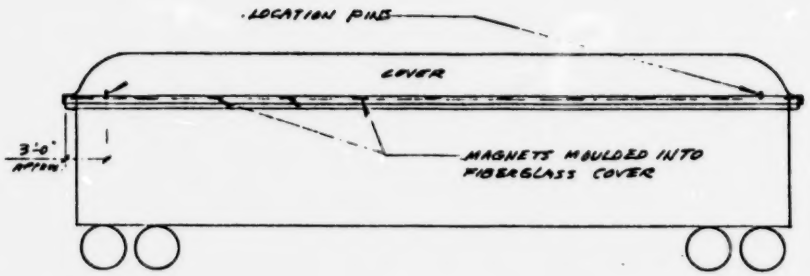


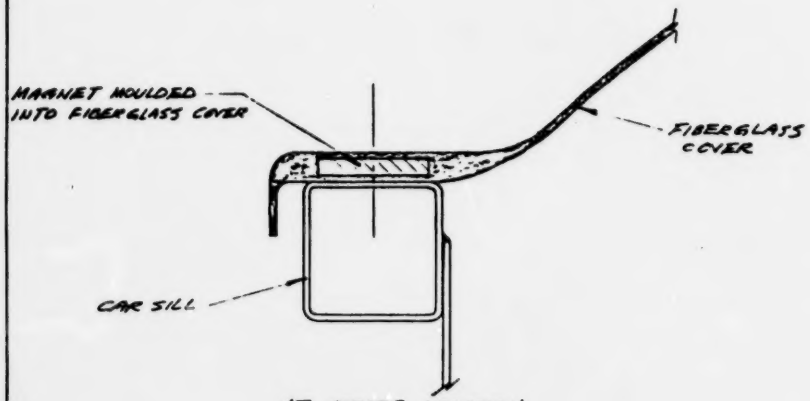
DWG NO:- SK-025

COVER WITH DOUBLE ACTION LATCH



AT LOCATION PIN

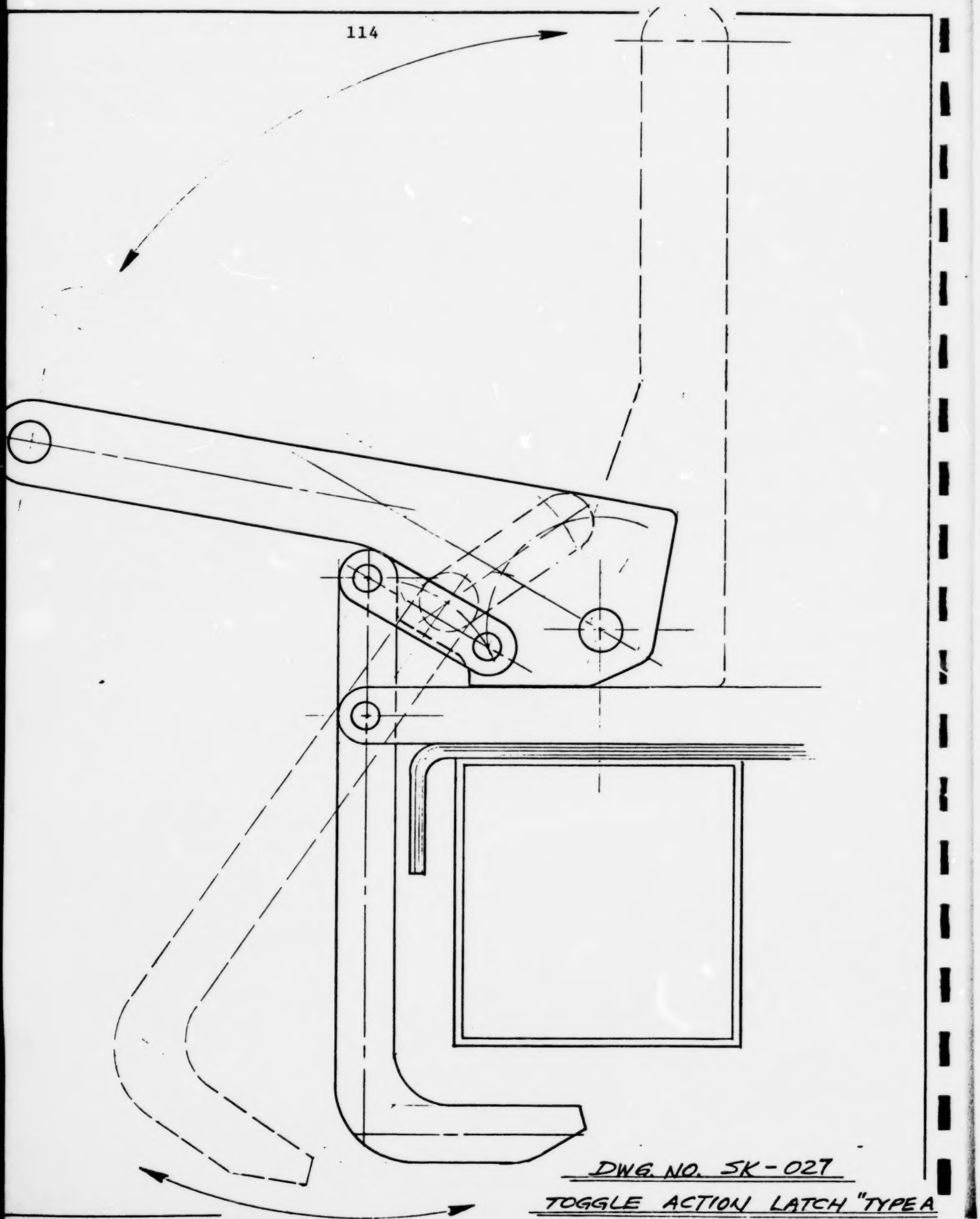




AT OTHER LOCATION

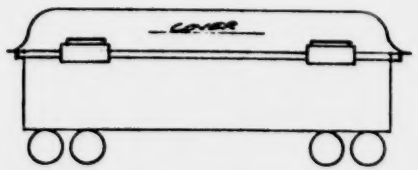
DWG. NO. SK-026

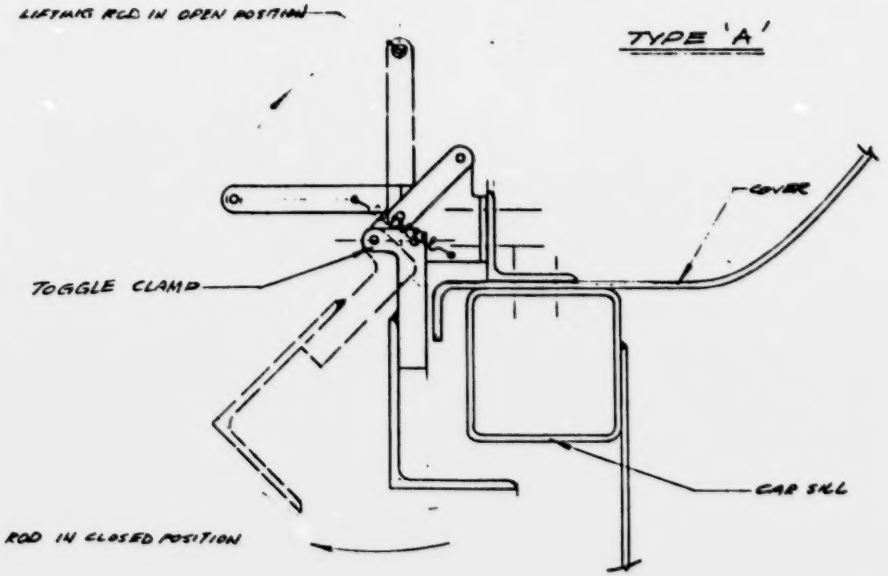
FIBERGLASS COVER WITH MAGNETIC HOLD DOWN

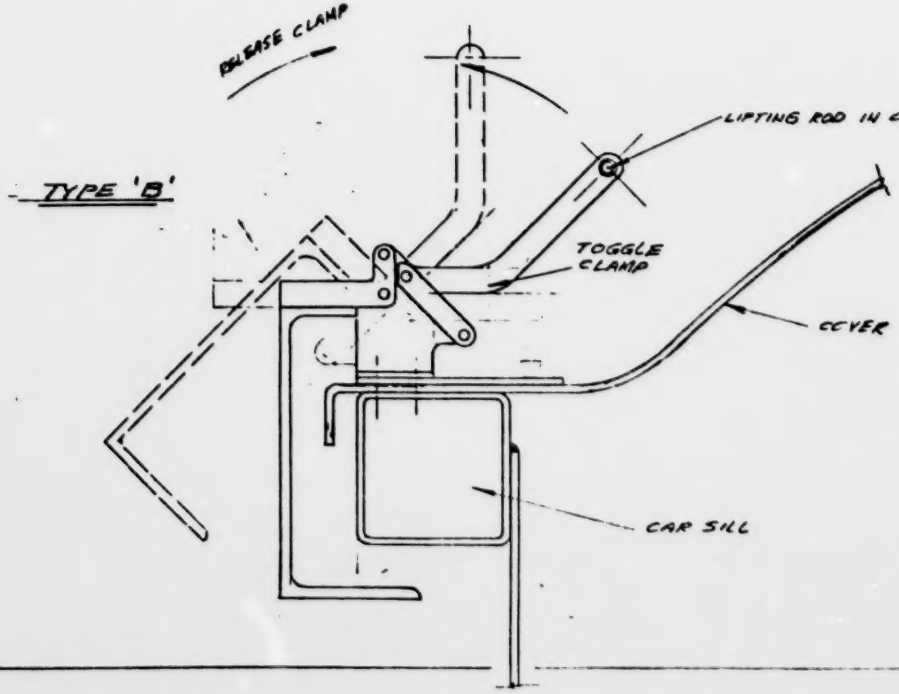


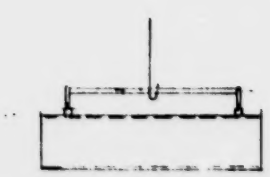
DWG. NO. SK-027

TOGGLE ACTION LATCH "TYPE A





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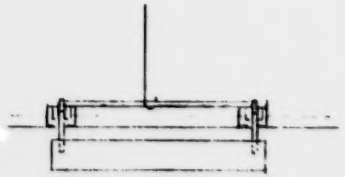
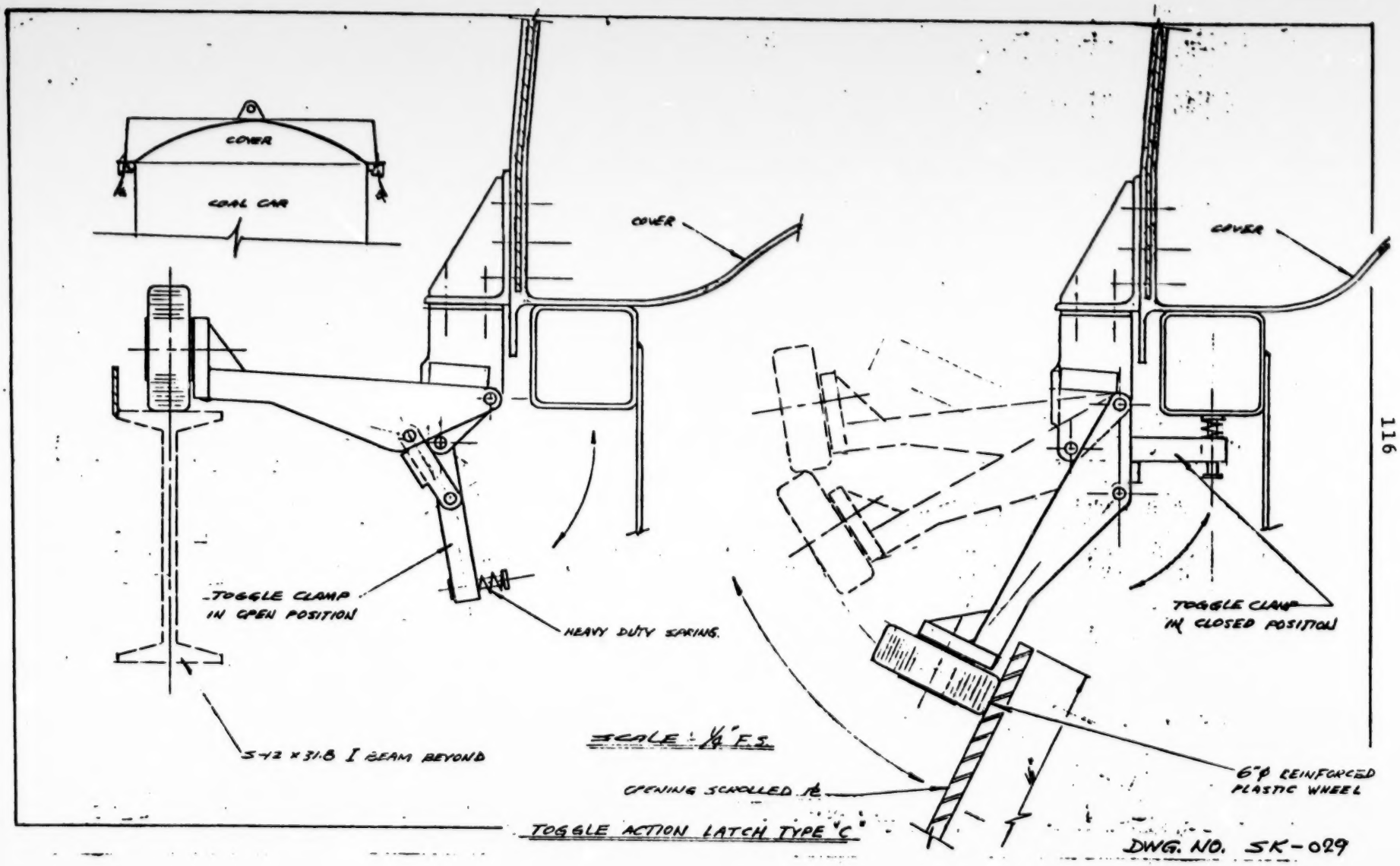

TYPE 'A'

DWG NO. SK-028
TOGGLE ACTION LATCH "TYPE B"



TOGGLE ACTION LATCH TYPE 'C'

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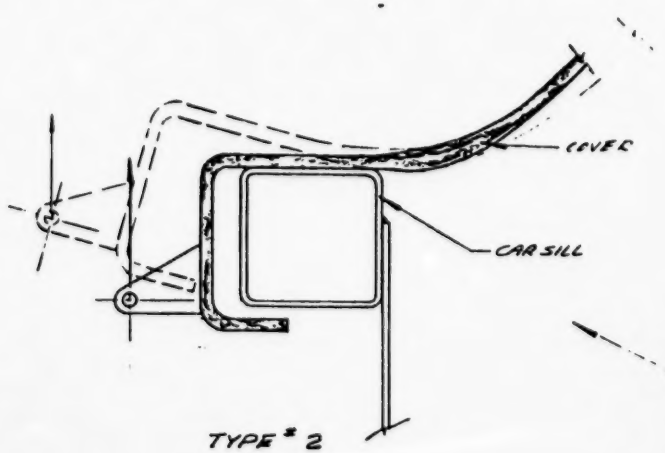
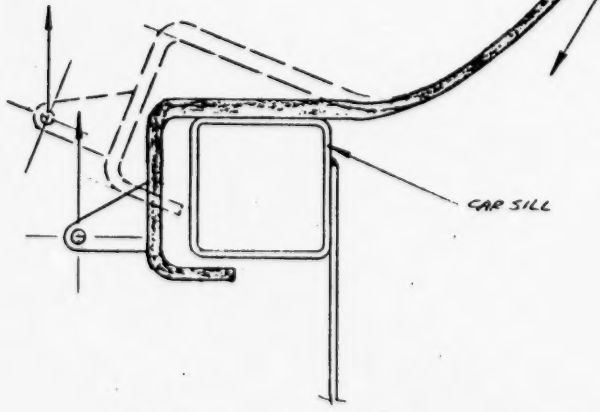
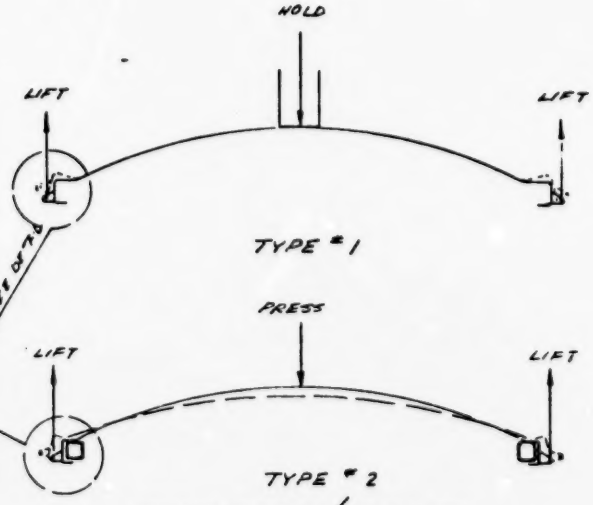


TYPE # 2

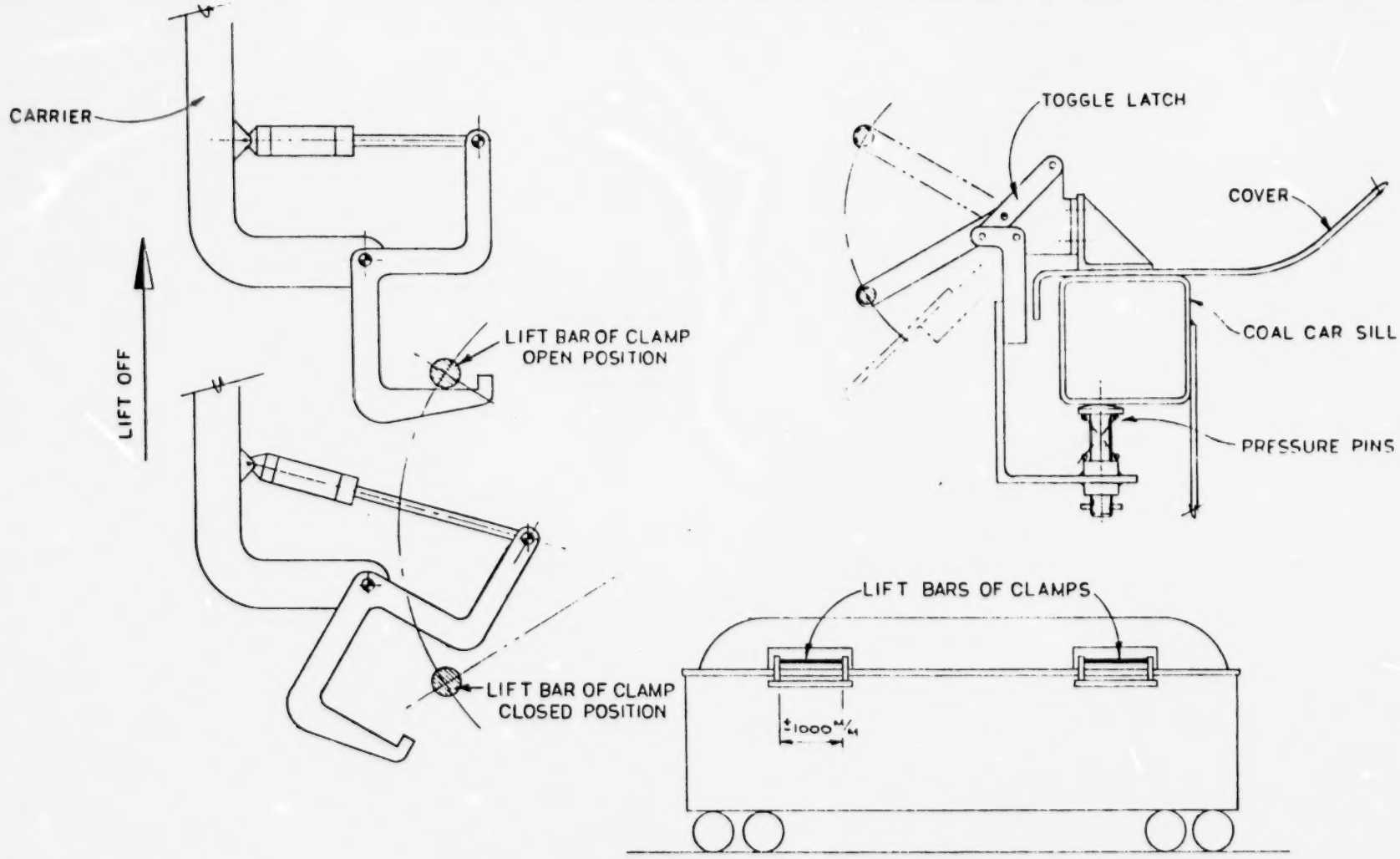


TYPE # 1

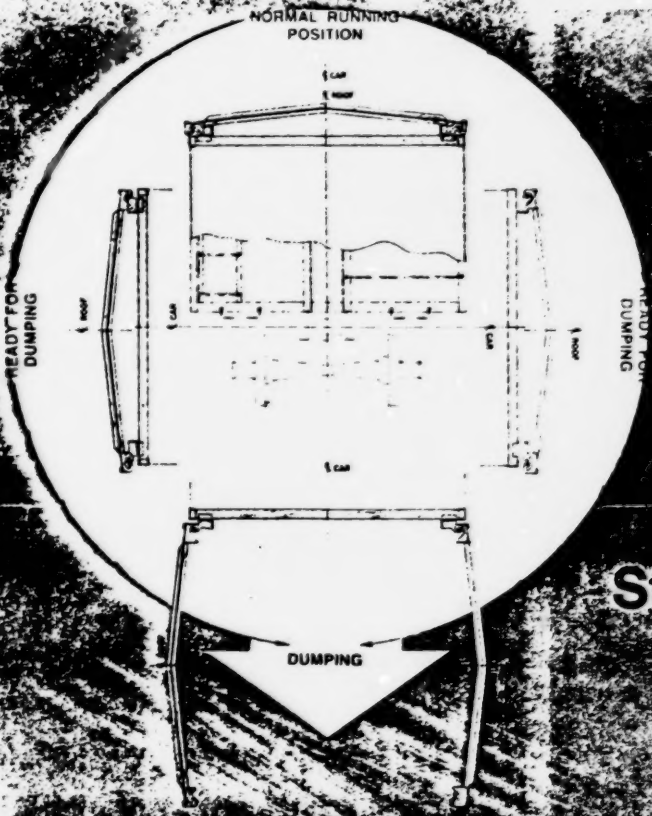


MOULDED RUBBER / PLASTIC ETC.

DWG NO SK-030
FLEXIBLE LIP
SEAL CAR COVER



TOGGLE LATCH AND LIFT OFF MECHANISM SK 031



Stanray Swing Roof

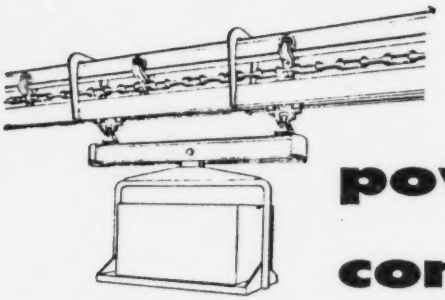
Stanray Corporation designed the exclusive Swing Roof, an entirely new concept developed to fill the need for covered cars where lading must remain absolutely dry. The Roof, with hinges on both sides, can be opened from either side rotation in a rotary car dumper.

A rotary car dumper is used where a large volume of material is unloaded instantly, with a minimum amount of labor. The Stanray Swing Roof, applied to high side gondola or open top hopper car, provides a method of shipping materials along with the economy of rotary dumping the car.

Simplicity of design and construction was a major consideration in the development of the Stanray Swing Roof. The revolutionary Swing Roof is held by gravity when in normal running position. Due to the unique contour of the hooks, they automatically lock to either side of the car when the Roof is open more than 15 degrees during dumping. Maximum opening for the Roof is a full 120 degrees.

Using the basic concept of moving large quantities of dry materials in open cars with the Swing Roof and unloading in a rotary car dumper, it can be seen that exceptional economies can be achieved with this readily adaptable method. The Swing Roof has only one moving part, the Roof itself. There are no slope sheets or complicated hatches, maintenance is minimal, dead weight is reduced as the number of moving parts is reduced. In addition, the total weight of the car is considerably decreased.

STANRAY CORPORATION



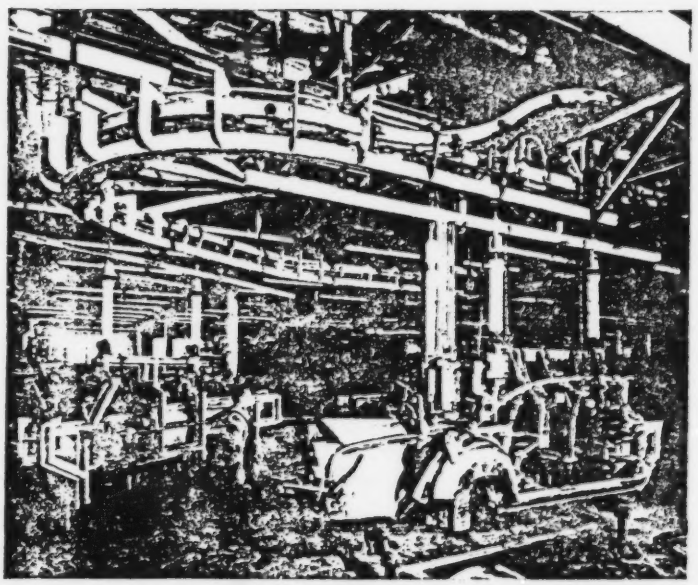
power and free conveyors

Power and free conveyors provide the wide operating flexibility necessary to handle parts, components and assemblies through fabricating and processing operations, thereby reducing manufacturing and handling costs. Coupled with suitable control systems, power and free conveyors automatically perform many comprehensive handling operations.

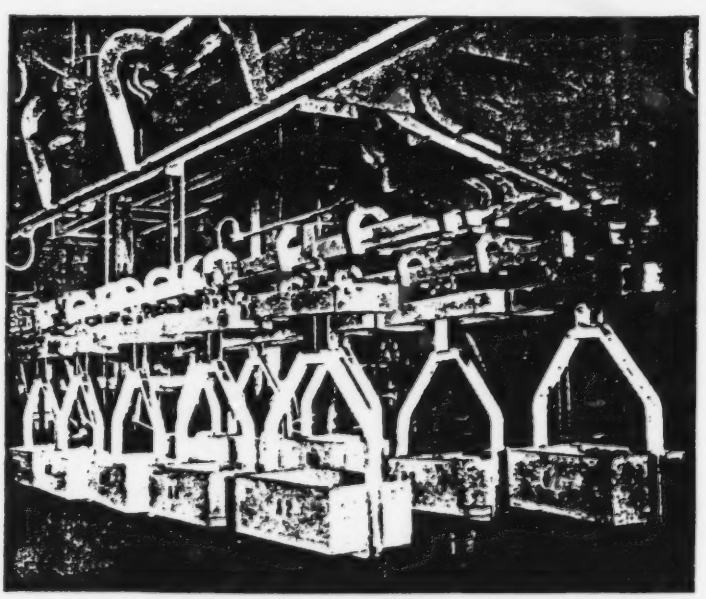
This combination of powered trolley conveyors and unpowered monorail type free conveyors has all the advantages of both in one integrated conveying system coupled with any desired amount of automatic control.

Two sets of track are used, usually suspended one above the other. The upper track is structural I-beam and carries the powered trolley conveyor. The lower, or free track, usually consists of two structural channels or angles and carries four wheel load trolleys from which carriers are suspended. Load trolleys have two integral pivoted dogs which engage pushers attached to the power conveyor trolleys or chain. Load trolleys are switched to and from adjacent unpowered free tracks on either or both sides of the main power and free conveyor while the power conveyor is moving. Load trolleys are hand or gravity propelled on free track runs. Manually or automatically controlled powered lifts are frequently used on free tracks to move load trolleys and carriers vertically to and from work stations and process enclosures such as paint dip or plating tanks or between track runs of different elevations.

Application of power and free conveyors by Link-Belt from the initial creative engineering, through manufacturing, installation, and testing assures the most appropriate and economical system to suit individual requirements.



Automobile body subassemblies in transit from storage to assembly.
Photo 39522



Load trolleys and carriers banked on free track storage lines after switching.
Photo 39533

Operating features

Routing of material • Dispatch mechanism on carriers permits material to be transported to selected points in the system and stopped.

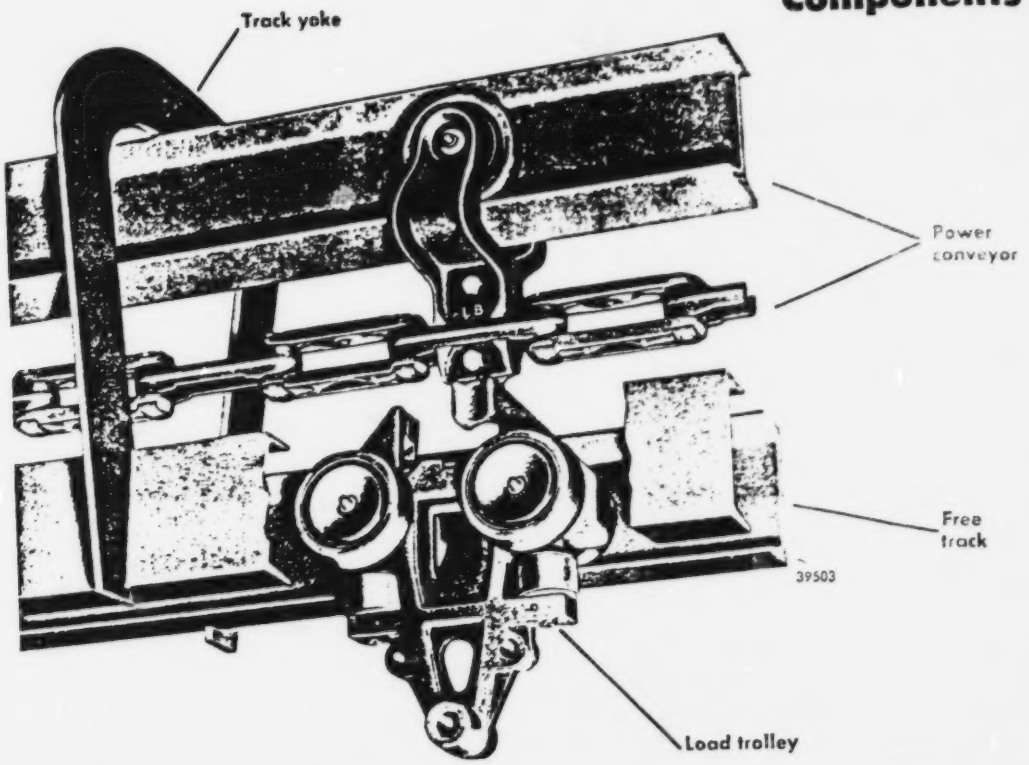
Storage • Carriers may be collected on free or powered tracks between operations or departments and held as long as desired.

Recirculation • Carriers dispatched to a station temporarily unable to accept them can circulate in the system until needed. Material can be returned to various work stations for rework or retest of rejected work.

Variations in load spacing and load speed • By using supplementary power conveyors with variable speed drives and with pushers spaced as required, load trolley spacing and speeds can be varied as required in the system to suit various processing operations. Material flow may be divided when necessary to maintain desired production.

Vertical movement of load trolleys • Powered lifts are used on free track runs to move load trolleys and carriers vertically to and from work stations, between track runs of different elevations, and for dipping operations.

Components



Power conveyors • 4" trolley conveyors with 4" I-beam track, Link-Belt Series 500 trolleys, and X458 Rivetless chain are usually used for power conveyors. For systems having moderate loads and inclines, pusher attachments on two wheel trolleys are used to engage and propel load trolleys on free track. For systems handling heavy loads or having steep inclines, pushers are mounted on the chain between two trolleys.

Free track • Two structural channels with flanges facing are usually used for free track on both powered and unpowered runs. The free track on powered runs is located below the power conveyor and is supported by steel yokes. 4" structural channel track is used for systems having moderate loads and 6" structural channel track is used for systems having heavy loads. Track systems for relatively light loads can be furnished with track made from two structural angles.

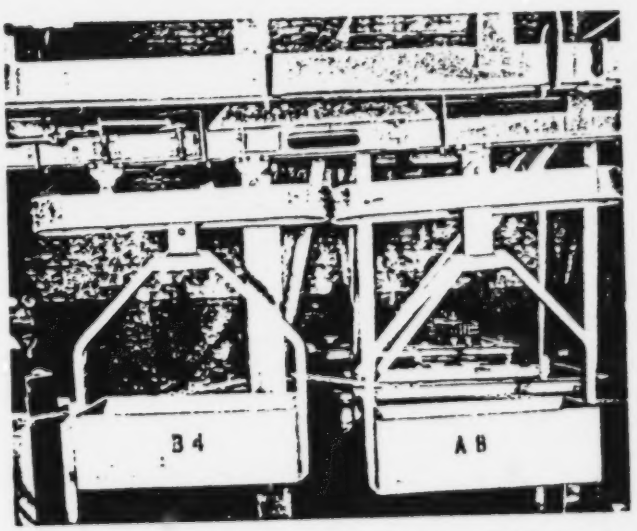
Load trolleys • Load trolleys consist of four ball bearing wheels, two vertical ball bearing guide rollers, and two pivoted pusher dogs all assembled to a rugged steel bracket having a pendant to suspend carriers.

The wheels are fully machined from steel tubing and are carburized and heat treated to give maximum life to rolling surfaces. Fully ground raceways and precision steel balls, fully caged for accurate spacing, minimize friction and assure smooth rolling. Wheels are provided with frictionless triple labyrinth metal seals and formed steel end plates having a pressure type lubrication fitting.

Steel dogs engage pusher attachments on power conveyor to propel load trolleys.

Vertical ball bearing guide rollers run on track flanges to effectively guide load trolleys on straight runs and around horizontal turns, assuring free movement.

Bumpers, load bars and carriers • Bumpers are generally provided on carriers for power and free conveyor systems. They prevent adjacent carriers from contacting one another when carriers are banked on unpowered free track ahead of switches, lifts or in storage lines. Bumpers usually support carrier dispatch mechanism. When two trolleys are required to suspend loads, bumpers also serve as load bars.



Single and double suspension bumpers with rectangular box carriers. Photo 39534

Carriers are designed to suit individual requirements. Assembly fixtures of many types as required for various operations may be incorporated. Many carriers can be arranged for automatic loading and unloading when required.

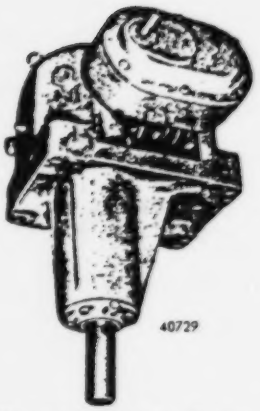
Dispatch mechanism • Carrier dispatch and control systems are usually mechanical (for simple routing) or electronic (for comprehensive systems) and are designed to provide any or all of the operating features shown on pages 522 and 523.

Drives

Link-Belt trolley conveyor drives are built in two general types: caterpillar drives and corner sprocket drives. Drive speeds, either constant or variable, up to a normal maximum of 150 feet per minute, are available. Drives for special applications requiring higher speeds or other special conditions can be furnished.

All trolley conveyor drives use Link-Belt worm gear speed reducers with an extended dry well type bearing housing on the output end, providing built-in shaft support and maximum capacity for overhung loads.

Speed reducers are connected to motors by V-belts, silent chains, roller chains or variable speed pulley units. Link-Belt drives have no open or exposed gearing. Drive assemblies are mounted on rigid structural steel frames.



Worm gear speed reducer

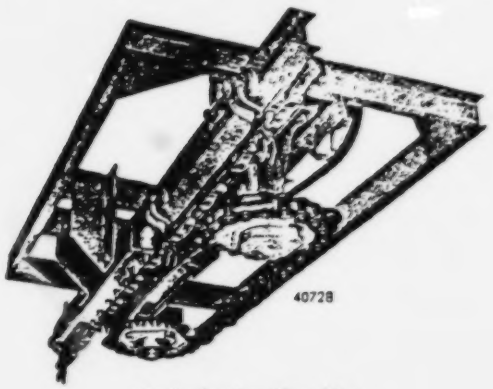
Caterpillar drives

Stationary caterpillar drives are widely used and can be located on any straight run of track. The caterpillar chain is an endless precision steel roller chain fitted with cast steel driving dogs which mesh with the Rivetless conveyor chain to drive the conveyor. The caterpillar and conveyor chains are held in proper engagement through the drive by a back-up bar on one side and a series of guide rollers on the other.

The hardened steel back-up bar contacts the caterpillar chain rollers holding it in position against the conveyor chain. The back-up bar is accurately shaped to provide controlled engagement and smooth disengagement of the chains without binding between conveyor chain and driving dogs.

The ball bearing guide rollers mount behind and contact the conveyor chain to prevent it from moving away from the caterpillar chain.

The caterpillar drive sprocket is mounted on the reducer output shaft and has an integral shear pin hub for overload protection. The ball bearing tail sprocket is mounted on a moveable bracket which permits adjustment of caterpillar chain tension. Caterpillar attachment components are mounted on a welded steel frame that bolts to the main drive frame. Caterpillar drives with many different chain pull capacities, speeds and other means of overload protection are available.

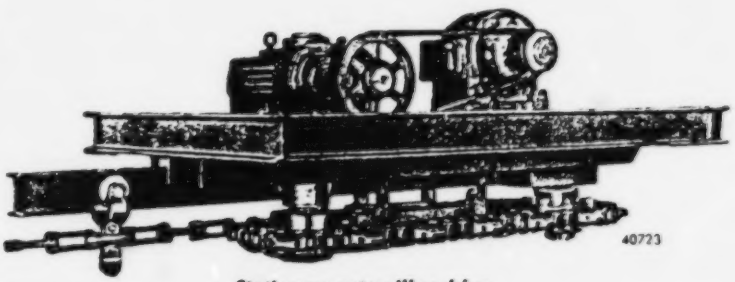


Typical caterpillar drive

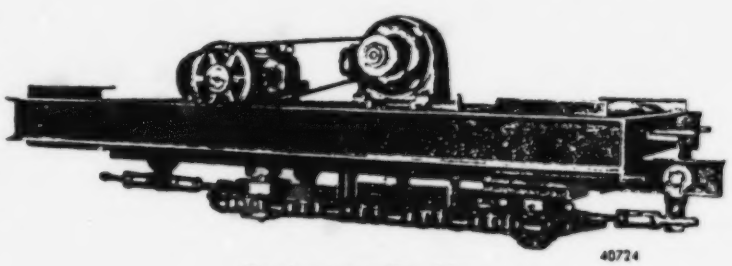
Floating caterpillar drives have all the advantages of the stationary caterpillar drive plus limit switch overload protection that eliminates the necessity of changing a shear pin when the unit is overloaded. Floating caterpillar drive frames are mounted on rollers which are supported and guided by an enclosing steel stationary frame. Movement of the floating frame is controlled by compact, constant modulus rectangular section helical springs. A limit switch is mounted on the floating frame and an adjustable tripping cam is provided on the stationary frame. As the drive is progressively loaded, the floating frame moves against the control springs and will trip the limit switch to stop the conveyor when the pre-set chain pull is exceeded.

This type of drive is very popular, particularly on production conveyors, as it minimizes down-time caused by drive overloading.

Floating caterpillar drives are available in the same sizes and chain pull ratings as stationary caterpillar drives.



Stationary caterpillar drive



Floating caterpillar drive

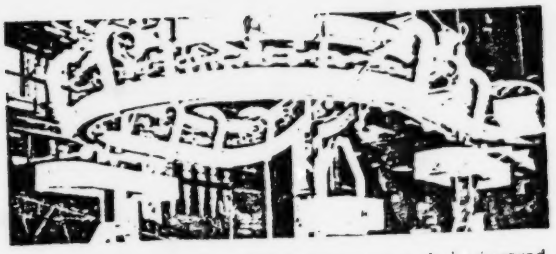
Horizontal turns • Turns used for combined power and free runs consist of accurately curved sections of both power and free tracks, a series of ball bearing rollers to guide power conveyor chain, steel yokes to support free track and a structural steel frame to rigidly support the entire assembly. Minimum radius is 36". Standard trolley conveyor roller turns are used on independent power conveyor runs (power conveyor runs not having free track). Turns for independent free track runs require only accurately formed curved track sections with support yokes.

Vertical curves • One method of varying track elevations on power and free conveyors is with vertical curves. They consist of accurately formed sections of I-beam and channel track. Minimum radius is 10'-0" measured to centerline of power conveyor track.

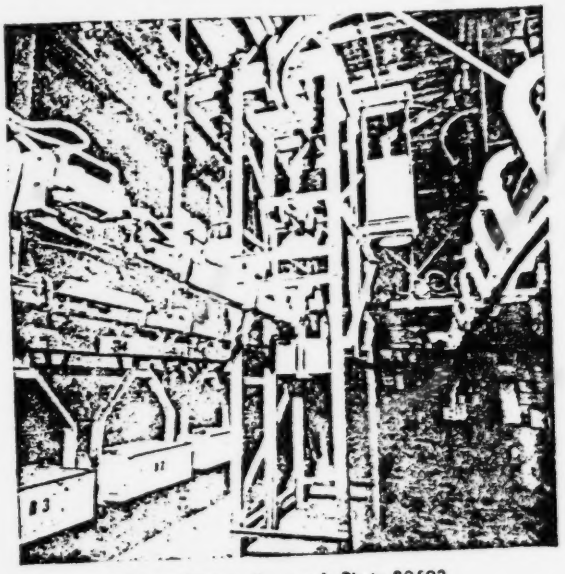
Powered lifts • Sections of free track on unpowered runs along with load trolleys and carriers are moved vertically with powered lifts. They are used to deliver work to and from work stations, for dipping operations of all types and to transfer carriers from one floor to another. Lifts are pneumatically, electrically or hydraulically operated and automatically or manually controlled. Multiple elevations may be accommodated when required.

Track switches (power and free) • 2 or 3-way tongue and 2-way plate type track switches are used to switch load trolleys to and from power and free runs. Switches are usually pneumatically powered and are manually or automatically controlled. Tongue switches have a pivoted section of free track and are used for moderate and heavy loads when ample clearance is available for switching. Plate switches use a moveable switch plate to transfer load trolleys and require less track length than tongue switches. They are used for moderate loads where required by path clearances.

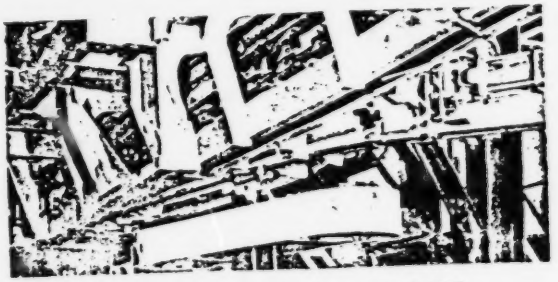
Track switches (unpowered free track) • 2 or 3-way stub switches are used to transfer load trolleys between unpowered runs of free track. They are manually or pneumatically powered. The pneumatic type may be manually or automatically controlled. Stub switches have sections of straight and curved track mounted on a moveable frame.



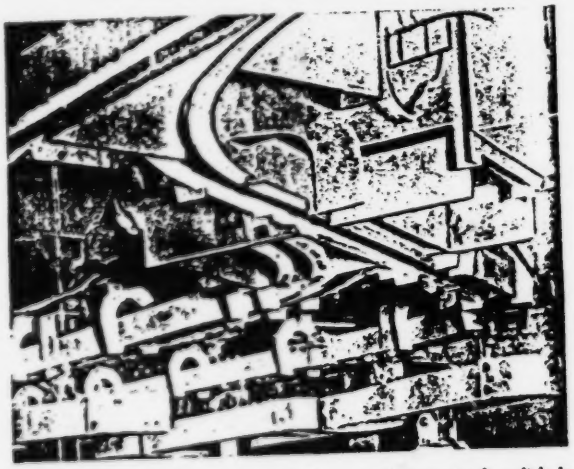
Power and free horizontal turn with vertical curve in background. Photo 39536



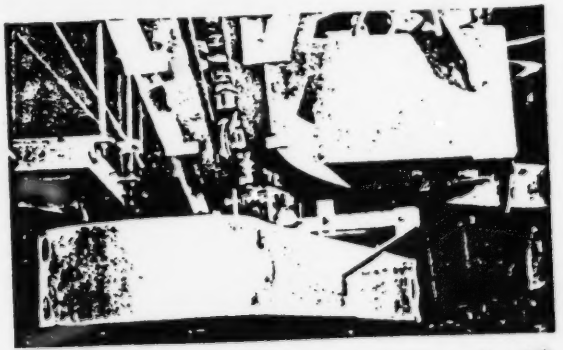
Powered lift on free track. Photo 39593



2-way tongue type track switch. Photo 39537



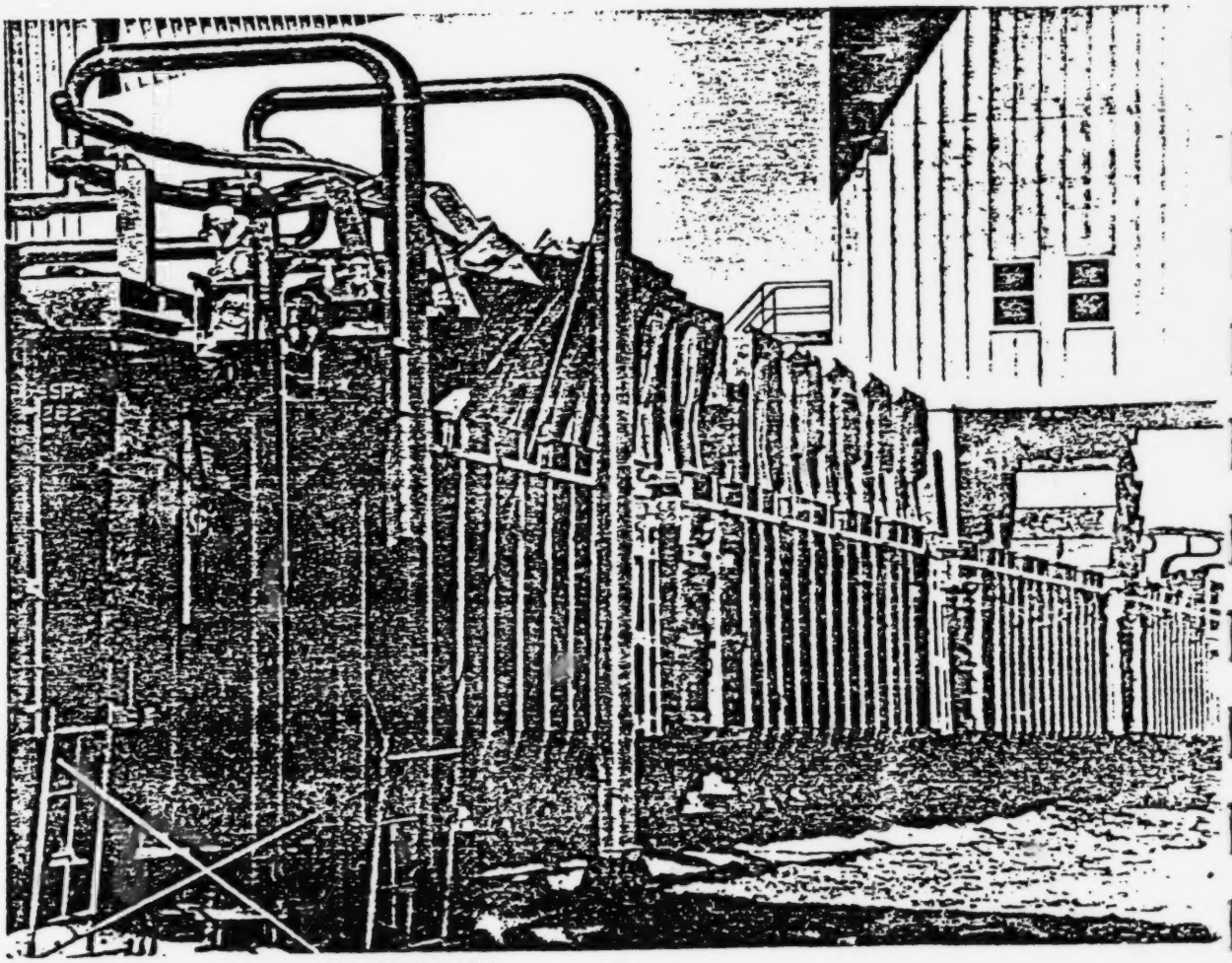
2-way plate type track switch with 2-way stub type track switch in background. Photo 39538



Load trolley being switched on 2-way plate type track switch. Photo 39535

PROGRESSIVE RAILROADING

. . . the executive viewpoint



ON THE MILWAUKEE ROAD: INNOVATION IN MOTION-LOADING

The "Flip Top" Lid

Reprinted from June, 1975 Issue

COVER STORY

The "Flip Top" Lid

It protects lading and opens and closes automatically on new unit trains of Milwaukee Road for the Big Stone Plant

Train approaches scroll for in-motion loading. Speed control is set for uniform mph as weight of train increases with loadings

The developers call it the "Flip Top" lid for railcars. It is the key to automatic in-motion loading of bulk material on a new Milwaukee Road unit-train movement.

It teams up with rotary dumping for no-delay unloading, thanks to the use of rotary couplers.

Loading is done at a steady one-third of a mile per hour, thanks to automatic preset speed control on the locomotives.

And with that combination, the new Big Stone Plant is supplied low-sulphur lignite in an unbroken "loop" on a 700-mile round trip in the Dakotas.

"When in full operation, three-million tons of lignite will be shipped annually over the 350 miles from the coal tipple at Gascoyne, in southwestern North Dakota, to Big Stone Plant, in northeastern South Dakota," says Marty Garelick, assistant vice president - chemicals, fuels, and metal products of the Milwaukee Road.

The "Flip Top" lid itself has been applied to a sturdy coal car design. Previously-built cars of essentially the same design have seen well over 1,000,000 miles of continued rugged service in other utility-served unit train operations. That is the Thrall Car gondola for transporting coal, featuring steel girder-type end and side supports for the 100-ton capacity body.

Without the lid, snow would accumulate in the cars on the return trip. Because lignite at loading has a temperature of 38 to 40 deg. it would melt the snow to form ice. This results in a formation of lignite and ice layers which do not dump completely, and which reduces the carrying capacity of the cars.

The lid provides an effective top seal for the cars. The prototype unit has withstood blizzard and gale conditions. For loading, they open and close automatically. Each lid has its own locking system. The locks unlatch for unloading so that the lids can open and then shut after unloading. All of that is done automatically and without the aid of power mechanisms.

The sequence of operations is shown in the photos accompanying this article.

Five-Section Roof Eliminates Stress

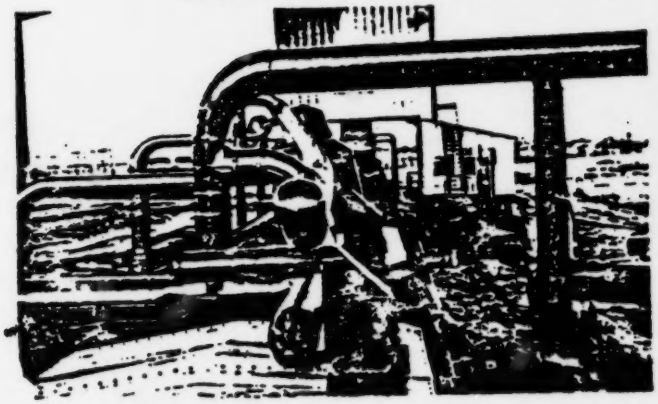
Each car has five separate roof sections designed and fabricated by Stanray Corporation. Having five sections facilitates raising the roof without imposing undue stresses upon it.

Each section is designed to seal tightly when lowered through a steel-to-steel interlock on the sides and ends of the car. Greater rigidity is imparted by diagonal reinforcing.

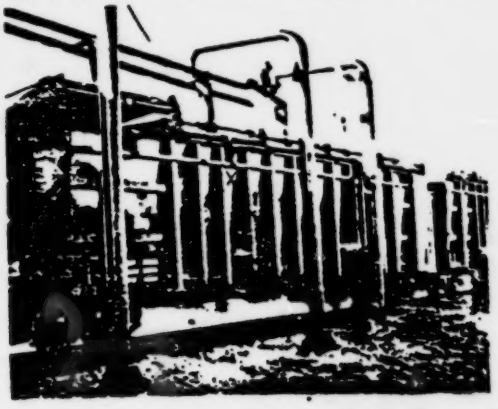
Each roof section also has two important functional components, one for automatically raising and lowering the lid, and the other for locking it when lowered.

The component for raising and lowering is a special contact bracket that consists of a vertical post and a horizontal steel roller. The vertical post had to be extended upward enough so that the horizontal roller was above the clearance line of the locomotive and caboose on the train. Hence, when a train reaches the loading area, this top portion of each car "threads" into what

Straight-on view of scroll as it engages roller part of lid assembly and lifts tops of cars as they move toward flood loader



At the last support for the automatic opening and closing system, a bent tube causes lid roller to snap-lock on car's side



begins as a horizontal ground-mounted 6-in. pipe, 460-ft. long, called a "scroll."

Since the "scroll" is contoured, it lifts each lid of the car until the lid is completely vertical, as the train passes the loading chute. Then, as the scroll once again curves downward and back toward the right side of the car, it eases the lid back down into a closed, and secured, position.

An "Automatic" Latch Release

That is all there is to it. Directly in line with the car-lifting fittings on each lid is a strong latch-type lock. Just under the top chord of the car can be seen a horizontal rub rail. Positioned with the rub rail, but protruding beyond it, is one end of the latch lock. A special weight-activated, lid-release wheel runs along the rub rail to push in that end of the latch just when the scroll is engaged to lift the lid. This presses against a spring at the fulcrum of the latch to disengage it and unlock the lid.

Then, at the other end of the loading cycle, the latch springs shut when the scroll permits the lid to drop back in place.

When unloading, the same type of contact system of a wheel running along the rub rail is used for disengaging the lid's lock before it begins to turn for unloading. As the dumper rotates, the car's turning motion acts to open the lids.

Index Cars for Precise Unloading

Just outside the dumper, a special mast engages the roller on the lid and forces the lid downward to press the locking latch in place.

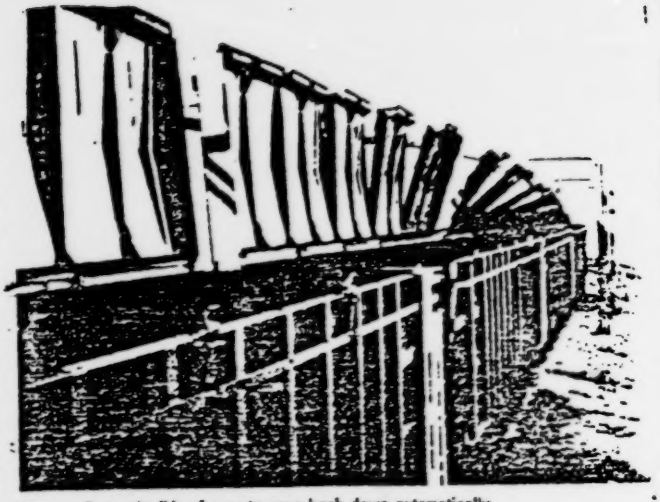
The train is unloaded at a rate of two minutes per car by a McDowell-Wellman rotary dumping system. The system has automatic indexing for positioning each car for turning. Special hydraulic rams clamp each car to the rotating mechanism for rapid turning without damaging the car sides.

This unique loading system was invented by Bechtel Corporation, the consulting engineering firm that designed and constructed the Big Stone Plant.

The patents on the efficient roof operating mechanism are held by the power companies. The Big Stone Plant itself is a combined venture of Montana Dakota Utilities, Northwestern Public Service Co., and the Otter Tail Power Company.

Thrall has completed the delivery of 232 of the 100-ton cars. They are owned by the Big Stone Plant and bear BSPX markings.

Because lignite is a relatively light material and, as shipped, has a substantial percentage of fines, wind loss may be a problem. This becomes critical with the volumes handled because a one-percent loss per load can mean a loss of one carload per 100 cars. Thus the lid serves the dual purpose of keeping moisture out and the entire cargo of lignite in.



How scroll permits lids of cars to ease back down automatically as train moves through loading cycle; when open, lid is vertical

For this movement, the Milwaukee Road will be operating two sets of equipment each on 48-hr. turnaround, six days a week. Every morning at 8:00, there will be a train at the mine to load and a train at the plant to unload. The power plant itself will burn at a full capacity of 358 tons per hour.

One-Man Operation

Loading at the mine will be at the rate of 3,000 tons per hour, requiring three hours and 15 minutes to load the train, or 30 cars per hour. There will be continuous loading from a tipple equipped with a pant-legged chute to switch the spout from one car to the next by push-button control. The flood loading chute is lowered into position after the locomotive passes. One man controls the entire continuous loading operation.

Special Caboose Remains Coupled

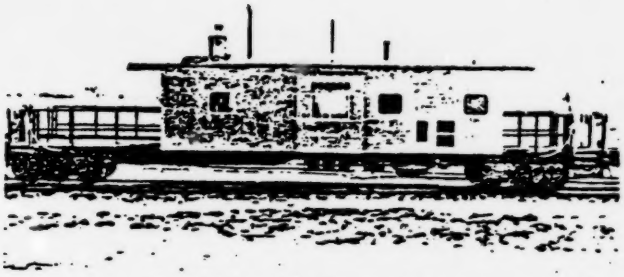
Line haul locomotives remain with the train throughout all loading operations, moving along at a steady 1/3 mph through the use of the Pace Setter control system of Vapor Corporation.

The system has a loop at both ends.

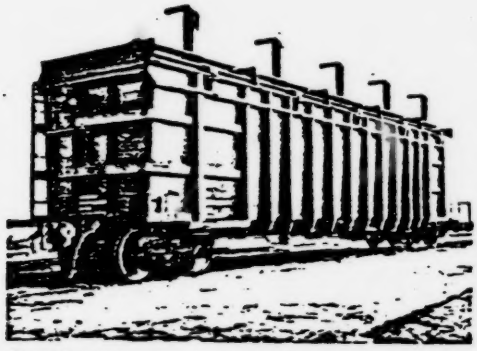
Because of the continuous movement of this operation, with assigned motive power, there is no need to break the air line except for special changeout of power and cars.

View from inside rotary dumper at power plant shows unlocked lids swung open to full vertical to clear load as car is turned

Close-up of snap-locking device for securing lids after dumping is completed. Similarly, disengaging device frees lids to unload



Special caboose is built to same length as the 100-ton car for Big Stone Plant. Length permits coupled, indexed movements



The 100-ton rotary dumping car incorporates structure and design that has seen extended service in similar unit train runs

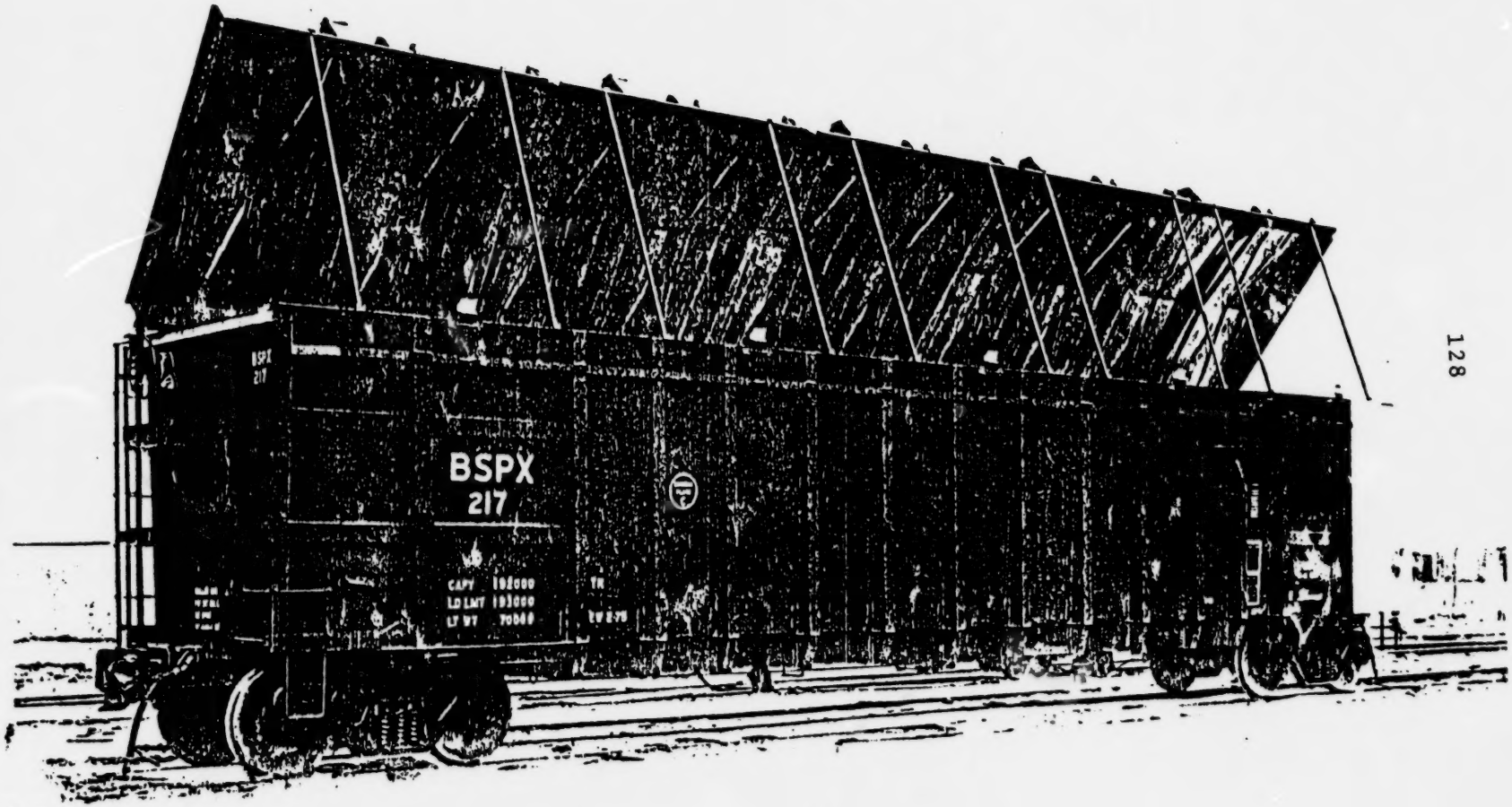
Lid keeps out moisture -and prevents loss, critical with the volumes handled

Two special cabooses were built by International Car Co. to fit into this service. They were designed to conform in length and other ways with the lignite cars so they could function as "anchors" for the train's last load during dumping operations. To accommodate wheel clamps the caboose trucks match wheel sizes with those of the other cars. The 56-ft., 3½-in. cars mount a standard Milwaukee caboose body on a long underframe. At one end is a standard step arrangement and at the other a sill step. Jutting out the roof is a thermo-electric generator providing 12-volts DC to charge the battery. Its propane fuel is in a tank mounted under the cars.

Judging by the remarkable performance of previous coal cars built by Thrall that have served as prototypes of these cars, changeout of the equipment will be rare. It is a rugged 100-ton car, presenting a clear cubical interior for 100 tons of lading, except for three interior supports on each side extending diagonally from floor to top chord.

The cars also are reinforced inward from each end over the truck area by two sturdy horizontal supporting members.

For greater ride stability, the cars also have 16-in. diameter center plates and the C-Pep center plate extension pads. One end of each car, that painted white, is also equipped with National rotary couplers, which is one of the keys to this effective, continuous-motion unit train operation. ■



THRALL CAR MANUFACTURING CO
CHICAGO HEIGHTS, ILLINOIS

PHASE THREE - REPORT

FOR

AIR POLLUTION CONTROL DIRECTORATE
ENVIRONMENT CANADA

Feasibility, Cost and Conceptual Design Study of Automated Coal Car Cover Systems Designed for Abatement of Fugitive Coal Dust.

DSS File No. 40SS.KE145-1-0458.

March 10, 1982

PHASE THREE

ECONOMIC ANALYSIS

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1.0 INTRODUCTION

PHASE THREE - FINAL REPORT

Background

The purpose of this report is to present the technical and cost feasibility of equipping Canadian rail cars with an automated loading/unloading cover system designed to abate all fugitive coal emissions.

The report is being undertaken at the request of the Department of Supply and Services for Environment Canada. The final report will be submitted to the Scientific Authority on or before March 15, 1982.

The report was undertaken in three phases, the first comprising background and information research, the second comprising an evaluation of conceptual designs and a selection of the most promising alternative. Phase three is the final report and includes phase one and phase two, plus an economic evaluation of cover systems in use on a typical coal transportation system.

This report addresses the third and final phase of the work.

ECONOMIC ANALYSIS

1.0 SUMMARY

An economic analysis was performed for two hypothetical coal rail haulage systems, with three different types of car covers; chemical binder spray, steel hinged "flip top" lid, and fibreglass removable cover.

Coal Rail Haulage System No. 1 was assumed to be from an existing mine in S.E. British Columbia to an existing trans-shipment terminal in Vancouver, British Columbia. This hypothetical system is 1100 km in length, and handles 10,000,000 tonnes/year. A chemical spray binding system is assumed to be in place. Steel or fibreglass cover systems would require retrofitting of existing systems.

Coal Rail Haulage System No. 2 was assumed to be from a new mine in N.E. British Columbia to a new terminal in Price Rupert, British Columbia. This hypothetical system is 1100 km in length, and handles 10,000,000 tonnes/year. As the system is new, it is assumed that it can be designed on a "greenfield" basis to accommodate handling of steel or fibreglass covers, or a chemical spray binding cover system.

"Greenfield" is meant to describe a situation where the original design of all coal loading, transportation, and unloading facilities can accommodate coal car cover systems of any chosen type.

A chemical spray binder application is currently the accepted way to control dusting in transit. A practical steel or fibreglass cover system was conceived and costed as an alternative solution.

The principal economic conclusion of this study is that for the two hypothetical systems studied, chemical spray binder application would create costs of some 38¢/tonne hauled, fibreglass covers would create costs of 43¢-44¢/tonne hauled (16%-19% more than sprays), and steel

covers would create costs of 78¢-80¢/tonne hauled (over two times as much as sprays).

It was assumed in the analysis that 0.15 tonnes of coal per car would be lost in transit with the chemical spray binder system and this product loss is included as a cost penalty to sprays in the economics.

The estimated cost of 37¢-38¢/tonne for chemical spray binders provides a system which is not 100% effective in eliminating fugitive coal dust emissions from rail cars. The estimated cost of 43¢-44¢/tonne for fibreglass covers will provide a system which is 100% effective in controlling coal dust emissions from within the cars.

2.0 BASIS FOR CAPITAL COSTS

2.1 Major Assumptions

Tonnage	10,000,000 tonnes/year
Haulage Distance (one way)	1100 km
Travel Time (one way)	36 hours
Loading Time	4 hours
Unloading Time	4 hours
Car Capacity	91 tonnes
Cars/Train	100

2.2 Number of Covers Required

Average cycle time/train:

Travel time (round trip)	72 hours
Loading	4 hours
Unloading	4 hours
TOTAL	80 hours

Average load per train:

100 cars x 91 tonnes/car = 9100 tonnes

Number of train trips/year

$$10{,}000{,}000 \frac{\text{tonnes}}{\text{year}} \times \frac{\text{train trip}}{9100 \text{ tonnes}} = 1099 \text{ train trips/year}$$

say 1100 train trips/year

Number of train sets/cars required:

$$1100 \frac{\text{trains}}{\text{year}} \times \frac{\text{year}}{(365 \times 24) \text{ hours}} \times \frac{80 \text{ hours}}{\text{train}}$$

= 10 train sets, or 1000 cars

Allow for 10% spare capacity in the train system, say 11 train sets, or 1100 cars.

Allow for 10% spare covers, for a total of 1210 covers, say 1200 covers.

2.3 Spray Application Facility Cost

Recent experience indicates that a spray application facility of existing design and effectiveness, complete with receiving, mixing, storage, building controls, and spray boom will cost about $250,000.

This figure was used for the No. 2 System (greenfield), while cost allocated to No. 1 System (retrofit) is nil, as it is assumed to already exist.

Summary: No. 1 System - nil; No. 2 System - $250,000.

A load leveller system may be required to increase effectiveness of the spray system and is not included within capital cost.

2.4 Cover Handling Systems

Steel Hinged Covers Handling

These covers remain on the cars at all times. The mine loading facilities require a lifting scroll pipe type of installation to lift the covers off the cars while loading. This is estimated to cost $100,000 for both a retrofit situation (No. 1 System) and a greenfield situation (No. 2 System).

In addition, design of all existing mine car loading systems is such that extensive structural modifications are necessary to allow the cover system to pass through the facility. See drawings SK-034, 035, and 036 in Appendix. A typical cost for these modifications is estimated to be $500,000. It is assumed that this cost is nil in a greenfield situation, as it can be incorporated into the design at no additional cost.

There is a problem with the cover being handled by the existing port rotary dumpers as the car clamping system in the dumper may interfere with the cover. See drawing SK-037 in Appendix. This needs to be addressed in car cover designs, but for this study it is assumed that

the car cover can be designed to work in the car dumper at no additional premium cost. In new port facilities, it is assumed that the car dumper clamping system design can be such that it will work with the cover, also at no additional premium cost.

Summary of Steel Hinged Cover Handling System Costs

Mine	No. 1 System	No. 2 System
Cover Handling System	$100,000	$100,000
Facility Retrofit	500,000	--
Port		
Cover Handling System	--	--

Fibreglass Lift-off Covers Handling

These covers require a custom-designed cover lift-off, convey, and replace system at both the loading and unloading points.

This has been researched on a preliminary basis and a conceptual design completed. See Section 4.6 of Phase II report.

Estimated cost of a fibreglass cover handling system at the mine and the port for both System No. 1 and 2 is $1,200,000 per installation. This includes a brush sweeping system to remove excess coal that has accumulated on the car sills at the loadout and at the dumper.

Summary of FRP Cover Handling System Costs

No. 1 System - $1,200,000
No. 2 System - $1,200,000

2.5 Covers

Steel Hinged Covers

Cover cost, based on a preliminary design, and quotes from fabricators is estimated to be $9,000 per cover.

Installation cost is estimated to be $1,500 per car, plus $400.00 per car to take a car out of service in the case of retrofitting. Total cost $1,900 per car in System No. 1.

Installation cost for System No. 2 is estimated to be $1,500 per car with no allowance for taking cars out of service.

Assuming supply of 1200 covers and installation of 1100 covers, costs will be as follows:

Summary of Steel Hinged Covers Cost

	System No. 1	System No. 2
Cover Supply	$10,800,000	$10,800,000
Cover Installation	2,090,000	1,650,000

Fibreglass Lift-off Covers

Cover cost, based on a preliminary design, and quotes from fabricators, is estimated to be $3,600 per cover, plus $1,200 per car for clamps, for a total of $4,800 per cover.

Installation costs include the cost of retrofitting all existing cars (System No. 1) to accommodate a standard cover length, plus installation of locating pins, an estimated total of $900, plus $400 per car to take them out of service for installation. Total cost $1,300 per car in System No. 1.

Installation costs for System No. 2 are estimated to be $900 per car, with no allowance for taking cars out of service.

Assuming supply of 1200 covers, and installation of 1100 covers, costs are as follows:

Summary of Fibreglass Lift-off Cover Costs

	System No. 1	System No. 2
Cover Supply	$5,760,000	$5,760,000
Cover Installation	1,430,000	990,000

TABLE ONE

CAPITAL COST SUMMARY TABLE

COAL RAIL HAULAGE SYSTEM NO.1 - S.E. B.C. TO VANCOUVER PORT (RETROFIT)

	CHEMICAL BINDERS	STEEL HINGED COVERS	FIBREGLASS LIFT-OFF COVERS
MINE:			
Spray Application Facility	--	--	--
Cover Handling System	--	$ 100,000	$1,200,000
Facility Retrofit	--	500,000	--
PORT:			
Cover Handling System	--	--	1,200,000
COVERS:			
Cover Supply	--	10,800,000	5,760,000
Cover Installation	--	2,090,000	1,430,000
TOTAL	--	$13,490,000	$9,590,000

COAL RAIL HAULAGE SYSTEM NO. 2 - N.E. B.C. TO PRINCE RUPERT PORT (GREENFIELD)

	CHEMICAL BINDERS	STEEL HINGED COVERS	FIBREGLASS LIFT-OFF COVERS
MINE:			
Spray Application Facility	$250,000	--	--
Cover Handling System	--	$ 100,000	$1,200,000
PORT:			
Cover Handling System	--	--	1,200,000
COVERS:			
Cover Supply	--	10,800,000	5,760,000
Cover Installation	--	1,650,000	990,000
TOTAL	$250,000	$12,550.000	$ 9,150.000

The capital costs summarized above are for systems that are 85% effective in the case of chemical binders and approaching 100% effective in the case of steel hinged covers and fibreglass lift-off covers.

3.0 BASIS FOR EQUIVALENT ANNUAL COSTS

3.1 Major Assumptions

Capital Cost Recovery

It was necessary to assume a realistic economic life for each type of cover system for this calculation. The economic life was assumed to be the estimated physical life of each component of the different cover systems. An interest rate of 15% was used to reduce capital costs to an annual basis. No consideration was made for the effect of income taxes or capital cost allowances (depreciation).

Component	Economic Life	Capital Recovery Factor @ 15%
Chemical Spray System	20 yr	0.1598
Fibreglass Lift-off Covers	10 yr	0.1993
Steel Hinged Covers	15 yr	0.1710
Steel/Fibreglass Cover Handling System	20 yr	0.1598

Operating Labour - $20.00 per manhour.

Transportation Cost - Average of 1.5¢ per tonne km, or $16.50/tonne for Haulage System No. 1 and 2.

Maintenance Costs

Assumed at a fixed percent of initial capital cost per year.

Chemical Spray System - 2%
Steel Cover Handling System - 1%
FRP Cover Handling System - 4%
Steel Covers - 2%
FRP Covers - 4%

Steel Cover Weight - 2272 kg (2.27 tonnes).
Fibreglass Cover Weight - 1088 kg (1.10 tonnes).
Chemical Binder Spray Weight - 365 kg (0.40 tonnes)
Coal Product Value - $65.00/tonne

Additional Maintenance Costs
on Rail Cars with No Turn-around

The steel cover design with covers hinged to the cars does not allow turn-around of the rail cars as is now done to equalize wear on the car wheels.

It was assumed that maintenance on rail cars is predominantly on the undercarriage with only minimal maintenance required on the car body.

It was further assumed that normal maintenance costs are 2% of the capital cost per car per year, and that this will double if the cars cannot be turned around.

The incremental cost of additional car maintenance is then 2% of the car capital costs/year.

3.2 Capital Cost Recovery Calculation

System No. 1 - Chemical Spray

Nil.

System No. 1 - Steel Covers

Mine Facilities	- $600,000 x .1598	=	$ 95,880
Port Facilities		=	--
Covers	- ($10,800,000 + $2,090,000) x .1710	=	2,204,190
	TOTAL		$2,300,070
	say		$2,300,100

System No. 1 - FRP Covers

Mine Facilities	- $1,200,000 x .1598	=	$ 191,760
Port Facilities	- $1,200,000 x .1598	=	191,760
Covers	- ($5,760,000 + $1,430,000) x .1993	=	1,432,967
	TOTAL		$1,816,487
	say		$1,816,500

System No. 2 - Chemical Spray

$250,000 x .1598 = $39,950
say $40,000

System No. 2 - Steel Covers

Mine Facilities - $100,000 x .1598	=	$ 15,980
Port Facilities -	=	--
Covers - ($10,800,000 + $1,650,000) x .1710	=	2,128,950
TOTAL		$2,144,930
say		$2,144,900

System No. 2 - FRP Covers

Mine Facilities - $1,200,000 x .1598	=	$ 191,760
Port Facilities - $1,200,000 x .1598	=	191,760
Covers - ($5,760,000 + $990,000) x .1993	=	1,345,275
TOTAL		$1,728,795
say		$1,728,800

3.3 Capital Labour Cost Calculation

Chemical spray facilities at existing mines operate essentially unattended when loading trains. A nominal charge of 4 manhours per train (4,400 man-hours/year) was allocated to allow for operating a spray facility. This includes labour for filling mix tanks and getting the system ready for train arrival.

4,400 manhours/year x $20.00 = $88,000/year.

The steel cover system is designed to operate unattended, so no operating labour is charged to this system.

Fibreglass cover handling system will require one man to operate the cover handling system at the mine and port.

Cost = 1 man x 4 hours/train x 1,100 trips/year x 2 x $20.00 = **$176,000.**

3.4 Maintenance Cost Calculation

System No. 1 - Chemical Sprays

Based on current replacement cost of $250,000, maintenance costs are $250,000 x .02 - $5.000.

System No. 1 - Steel Hinged Covers

Mine Facilities - $600,000 x .01		= $ 6,000
Port Facilities		= --
Covers	- ($10,800,000 + $2,090,000) x .02	= $257,000
	TOTAL	$263,800

System No. 1 - FRP Lift-off Covers

Mine & Port Facilities	- $2,400,000 x .04	= $ 96,000
Covers	- ($5,760,000 + $1,430,000) x .04	= 287,600
	TOTAL	$383,600

System No. 2 - Chemical Sprays

Mine Facilities - $250,000 x .02	= $ 5,000

System No. 2 - Steel Hinged Covers

Mine Facilities - $100,000 x .01		= $ 1,000
Port Facilities -		= --
Covers	- ($10,800,000 + $1,650,000) x .02	= 249,000
	TOTAL	$250,000

System No. 2 - FRP Lift-off Covers

Mine & Port Facilities	- $2,400,000 x .04	= $ 96,000
Covers	- ($5,760,000 + $990,000)	= 270,000
	TOTAL	$366,000

3.5 Energy Cost Calculation

Energy (electricity) consumption of all systems is very minimal, and is assumed to be nil for the purposes of this evaluation.

3.6 Raw Materials Cost Calculation

No raw materials are used in the steel or fibreglass cover system. Figures of from 10-12¢/coal tonne are reported from several operators, and other references for spray materials of latex or bitumen type which have proved 85% effective. A cost figure of 12¢/coal tonne was used in this analysis.

Annual costs = \$0.12 x 10,000,000 = \$1,200,000.

If this cost is increased by application of more material to achieve better dusting control (and it is not established to our knowledge that more spray equals less dust) this cost will offset the cost of product losses. The overall cost per tonne of coal shipped is not likely to change.

3.7 Car Underutilization Cost Calculation

The weight of the covers requires that the car be loaded to less than design capacity in order that overloads are not present.

This is quantified on a commercial basis by the railway in a typical contract, on a "take or pay" concept. Specifically, several contracts are written which calculate freight charges with a 261,000 lb gross weight minimum, and 263,000 lb gross weight maximum, i.e. 1-ton loading "window" is specified in the contract.

The philosophy of this agreement is to encourage maximum utilization of the railway fleet, with no overloads.

For the purpose of this economic evaluation, it was assumed that the cover weight amounts to a freight cost penalty to the operator equal to the cost of shipping the weight of the cover.

Note that the coal not shipped in a train is not lost revenue to the producer. The railway simply has to provide more trains to haul the coal, which is a cost reflected in the freight charge.

This is calculated as follows:

Chemical Spray

0.4 tonnes/car x 100 cars/train x 1,100 trains/year x $16.50/tonne = $726,000/year.

This is somewhat of a hypothetical figure, as in the real loading situation, cars are weighed before spraying. However, in a strict technical sense, it can be argued that the cars should be weighed after spraying, or underloaded by this amount.

Steel Hinged Covers

2.27 tonnes/car x 100 cars/train x 1,100 trains/year x $16.50/tonne = $4,120,000/year.

Fibreglass Lift-off Covers

1.10 tonnes/car x 100 cars/train x 1,100 trains/year x $16.50/tonne = $1,996,500/year.

3.8 Additional Car Maintenance Cost Calculation

For steel covers only, to assess cost of additional wheel maintenance due to inability to turn cars around, costs are:

Capital cost per car: $60,000.
Additional Maintenance Costs = $60,000/car x 1,100 cars x .02
= $1,320,000/year.

3.9 Product Losses Cost Calculation

Steel/Fibreglass Covers

It is assumed that losses from cars with steel or fibreglass covers is nil.

Chemical Sprays

Several studies have indicated that 0.15 tonnes/car (0.15%) is a loss which can be expected with chemical spray covers, as the cover crust is not 100% effective in controlling dusting.

At $65.00/tonne, this is equivalent to a loss of 0.15 tonnes/car x 100 cars/train x 1,100 trains/year x $65.00/tonne = $1,072,500 per year.

It is assumed that the coal losses from "empty" cars returning to the mine is negligible.

3.10 Frozen Coal Cost Calculation

Several reports have indicated that between 1 to 5 tonnes of coal which has frozen to some cars in winter months can be expected.

It is not well established whether the moisture in the coal which causes freezing comes from the preparation plant process or the natural environment (snow, rain) enroute. It is understood that this problem is currently under study by some producers and the railway.

For purposes of this evaluation, it was assumed that:

- Frozen coal is caused for the most part by moisture from the environment; i.e. steel or fibreglass covers will eliminate the problem, whereas chemical sprays will not.

- The problem can be expected to occur 25% of the time (four winter months, mid November to mid March), and will average at 1.5 tonnes/car.

The best way to quantify this in dollar terms is to calculate it as a freight cost, i.e.:

1,100 trains/year x 0.25 x 1.5 tonnes/car x 100 cars/train x $16,50/tonne = $680,625, say $680,600.

Again note that the cost of coal not shipped is not lost revenue to the producer. The railway has to provide more trains to haul the coal displaced by frozen coal, which is a freight charge to the producer, i.e. additional transportation cost, but not additional lost sales revenue.

3.11 Other Costs

There are miscellaneous other costs for chemical spray systems which should properly be considered in the evaluation. However, they will increase the cost of chemical spray systems at most by 1¢/tonne hauled.

These costs include such things as:

- Spray damage to cars and cost of cleaning of rail cars. (Maintenance costs will increase somewhat).

- Back-up spray system to ensure 100% coverage of coal in cars in the event of primary spray system failure. (This is visualized as an additional spray boom installed in the existing system).

TABLE TWO

COST COMPARISON SUMMARY TABLE

COAL RAIL HAULAGE

SYSTEM NO.1

Equivalent Annual Costs:	CHEMICAL BINDERS	STEEL HINGED COVERS	FIBREGLASS LIFT-OFF COVERS
Capital Recovery	--	$ 2,300,100	$ 1,816,500
Operating			
Labour	88,000	--	176,000
Maintenance	5,000	263,800	383,600
Raw Materials	1,200,000	--	--
Transportation			
Car Underutilization	726,000	4,120,000	1,996,500
Additional Rail Car Maintenance	--	1,320,000	--
Product Losses	1,072,500	--	--
Frozen Coal	680,600	--	--
Total Equivalent Annual Cost	$ 3,772,100	$ 8,003,900	$ 4,372,600
Cost/Tonne	38¢/tonne	80¢/tonne	44¢/tonne

The costs summarized above are for a system that is 85% effective in the case of chemical binders and approaching 100% effective in the case of steel hinged covers and fibreglass lift-off covers.

TABLE THREE

COST COMPARISON SUMMARY TABLE

COAL RAIL HAULAGE

SYSTEM NO. 2

Equivalent Annual Costs:	CHEMICAL BINDERS	STEEL HINGED COVERS	FIBREGLASS LIFT-OFF COVERS
Capital Recovery	$ 40,000	$ 2,144,900	$ 1,728,800
Operating			
Labour	88,000	--	176,000
Maintenance	5,000	250,000	336,000
Raw Materials	1,200,000	--	--
Transportation			
Car Underutilization	726,000	4,120,000	1,996,500
Additional Rail Car Maintenance	--	1,320,000	--
Product Losses	1,072,500	--	--
Frozen Coal	680,600	--	--
Total Equivalent Annual Cost	$ 3,812,000	$ 7,834,900	$ 4,267,300
Cost/Tonne	38¢/tonne	78¢/tonne	43¢/tonne

The cost summarized above is for a system that is 85% effective in the case of chemical binders and approaching 100% effective in the case of steel hinged covers and fibreglass lift-off covers.

4.0 COST OF BUILDING LOADING AND UNLOADING FACILITIES

The following cost figures are included only for the purposes of placing the cost of cover systems in perspective with other components of the coal rail hauling system.

4.1 Loading Station

Recent cost estimates indicate that a dual weigh bin - surge bin type loadout will cost approximately $2,500,000.

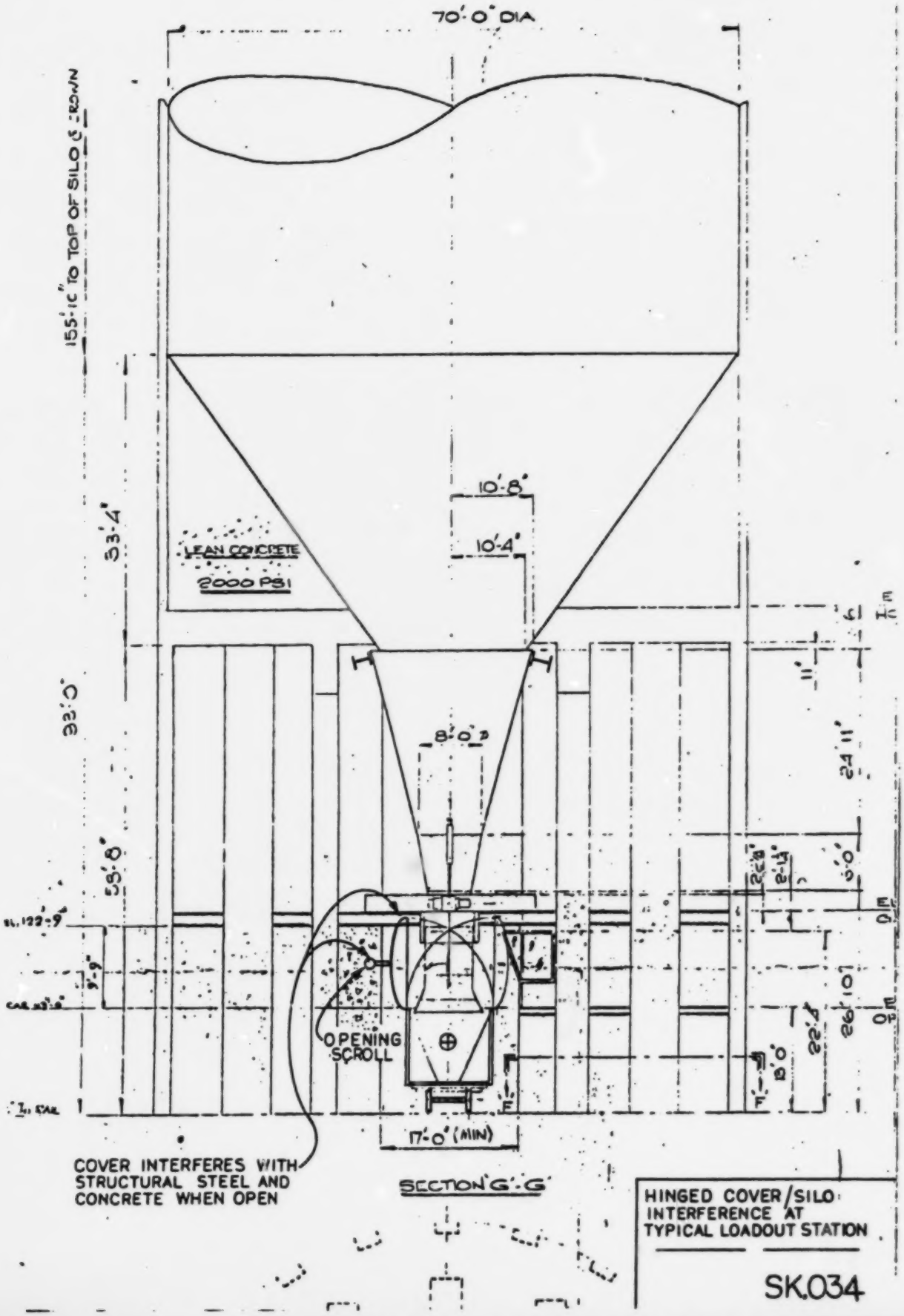
4.2 Loading Silo

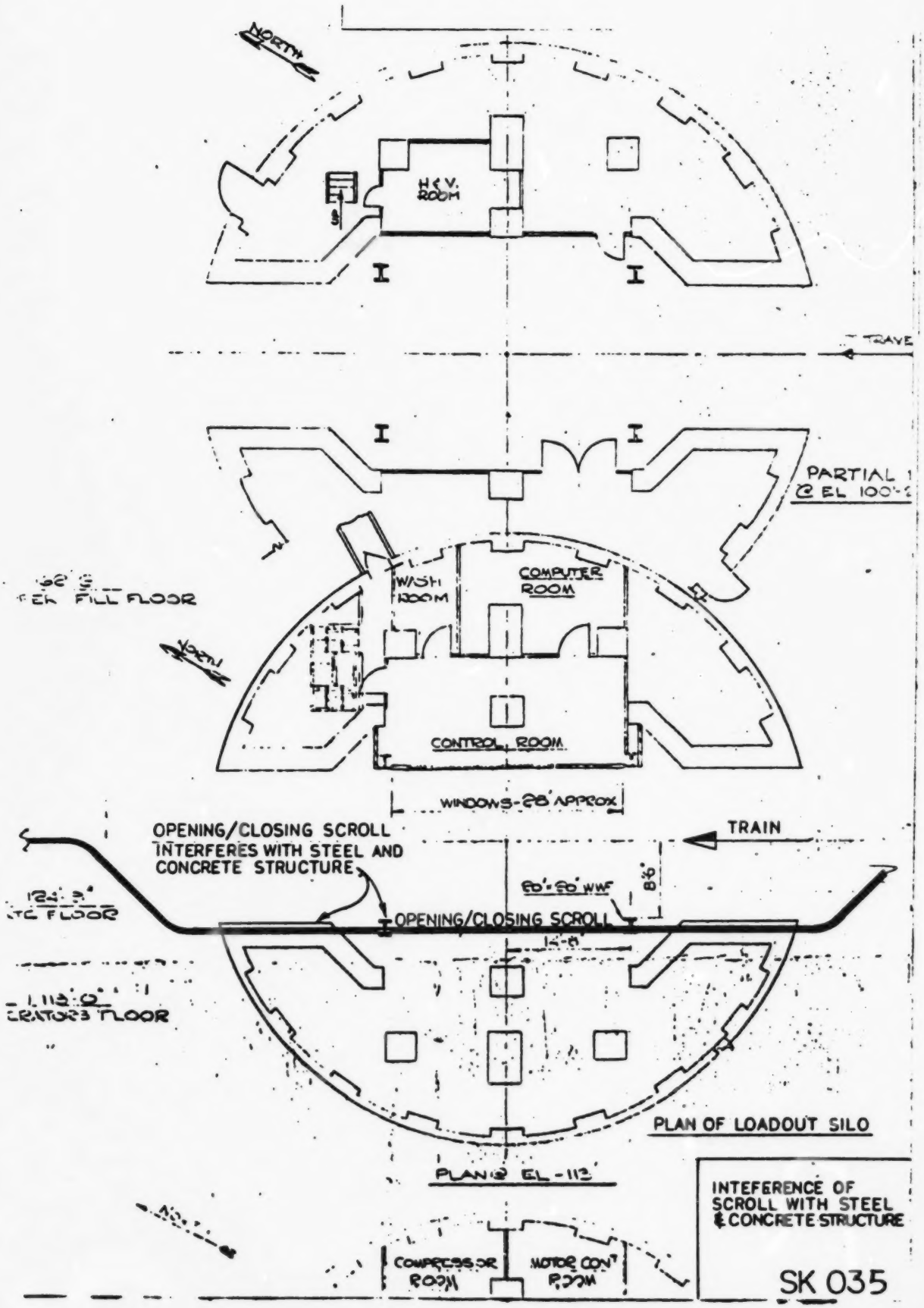
A silo type of loadout built from scratch will cost approximately $10,000,000.

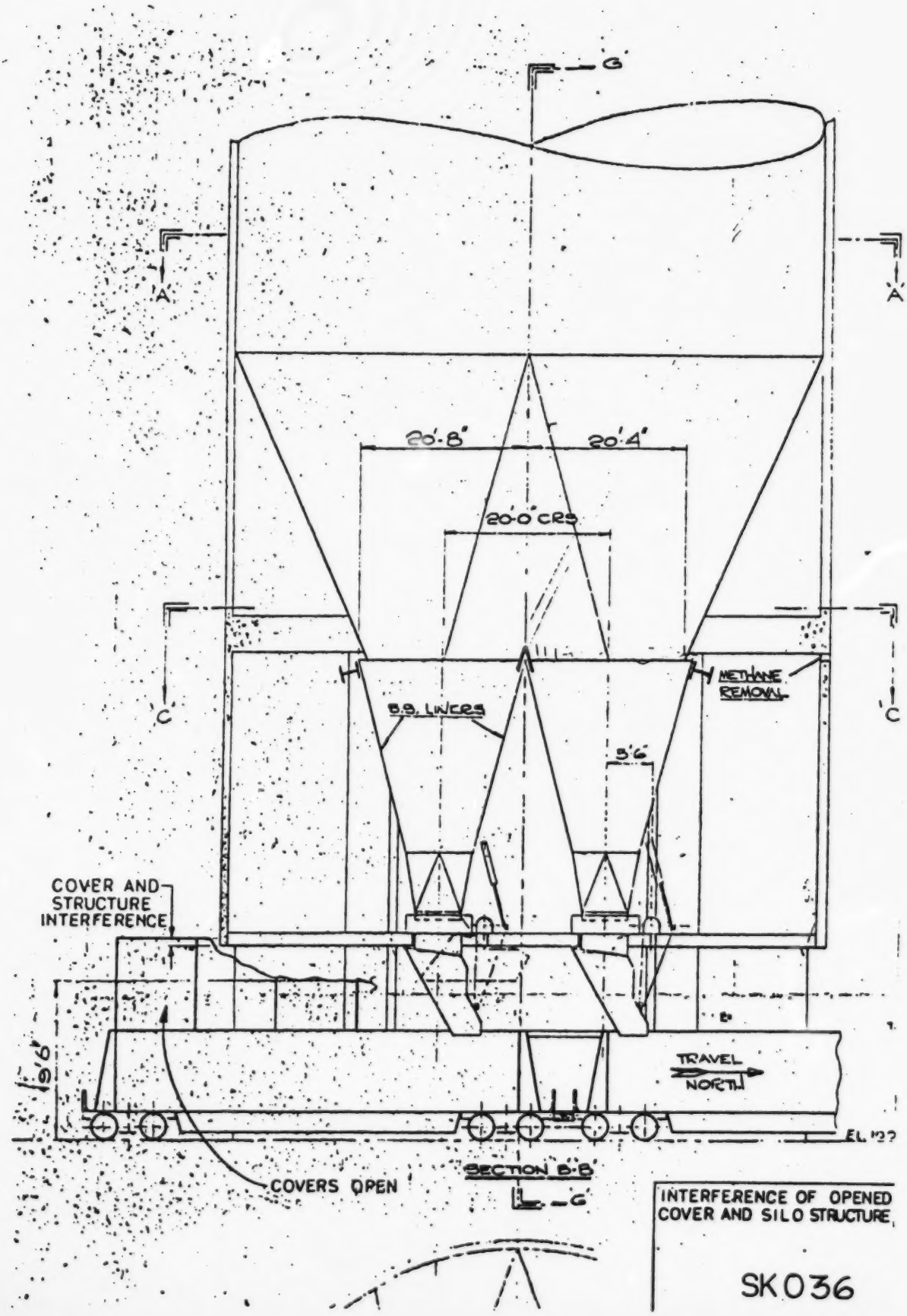
4.3 Dumping Station

A complete rotary dumper facility, including car positioner and wheel clamper, will cost approximately $3,000,000.

APPENDIX - End View of Dumper
- Silo/Cover Interference
- Silo/Scroll Interference
- Plates

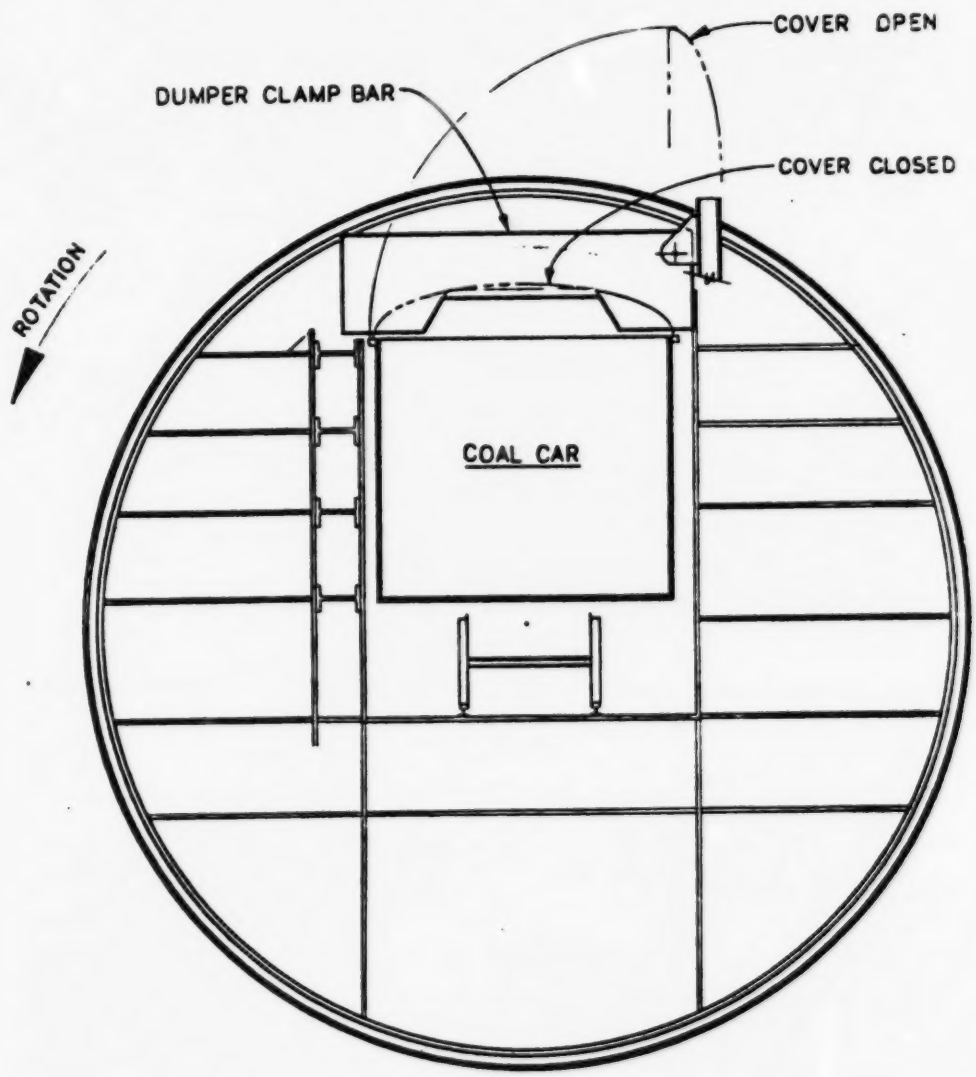

70'-0" DIA
155'-1C" TO TOP OF SILO @ CROWN
33'-4"
33'-0"
58'-8"
10'-8"
10'-4"
LEAN CONCRETE
2000 PSI
8'-0"
OPENING
SCROLL
17'-0" (MIN)
COVER INTERFERES WITH
STRUCTURAL STEEL AND
CONCRETE WHEN OPEN
SECTION G-G
HINGED COVER/SILO
INTERFERENCE AT
TYPICAL LOADOUT STATION
SK.034


NORTH
H&V ROOM
I
I
TRAVE
I
I
PARTIAL
@ EL 100'-
WASH ROOM
COMPUTER ROOM
CONTROL ROOM
WINDOWS-28' APPROX
TRAIN
OPENING/CLOSING SCROLL
INTERFERES WITH STEEL AND
CONCRETE STRUCTURE
ED'-ED' WWF
8'6"
OPENING/CLOSING SCROLL
14'-9"
PLAN OF LOADOUT SILO
PLAN @ EL -113'
COMPRESSOR ROOM
MOTOR CON' ROOM
INTEFERENCE OF
SCROLL WITH STEEL
& CONCRETE STRUCTURE
SK 035



INTERFERENCE OF OPENED COVER AND SILO STRUCTURE.

SK036



END VIEW OF DUMPER

INTERFERENCE OF DUMPER CLAMP BAR WITH HINGED COVER

SK 037

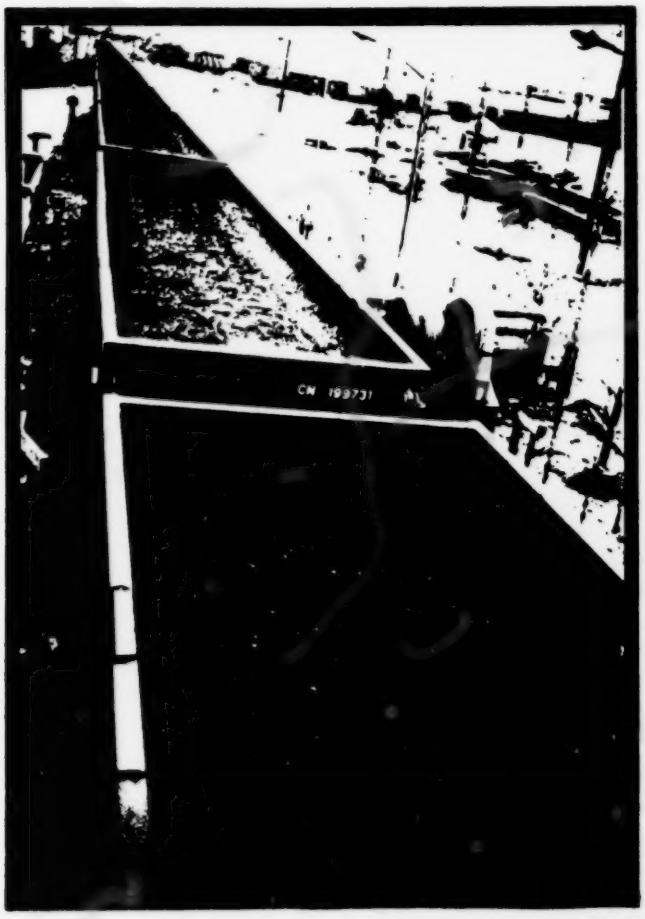


PLATE #1
COAL CARS ENTERING ROTARY DUMPER AT NEPTUNE BULK TERMINALS, NORTH VANCOUVER

PLATE #2
THREE TYPES OF COVERS ON CONCENTRATE CARS AT VANCOUVER WHARVES

PLATE #3
FIBREGLASS COVERS FOR
CONCENTRATE CARS,
VANCOUVER WHARVES

PLATE #4
FIBREGLASS COVERS FOR
CONCENTRATE CARS,
VANCOUVER WHARVES

PLATE #5
GANTRY CRANE LIFTING
OFF A LORNEX COVER
FROM A CONCENTRATE
CAR, VANCOUVER WHARVES

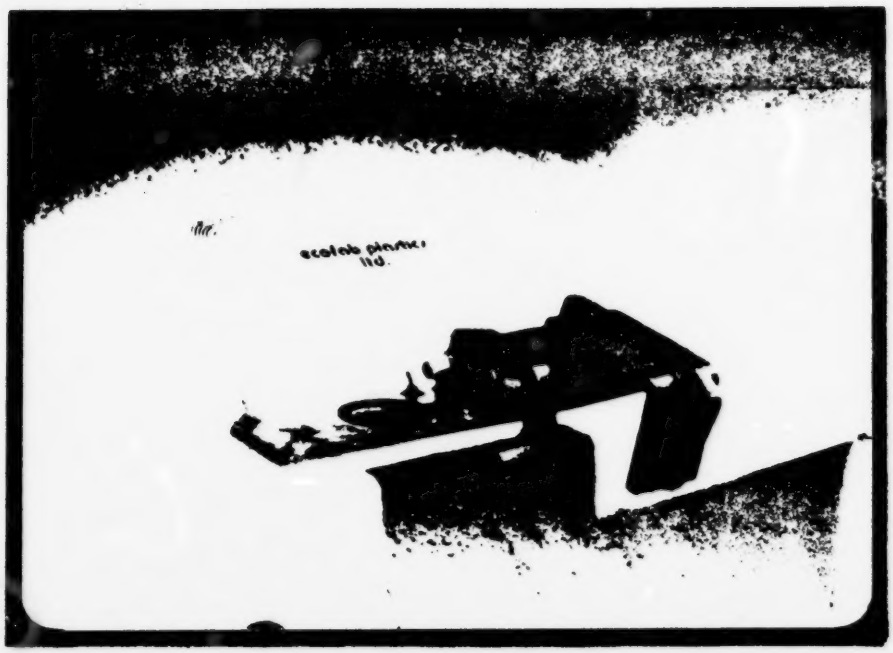


PLATE #6
CLAMP ON CONCENTRATE
CAR COVERS,
VANCOUVER WHARVES

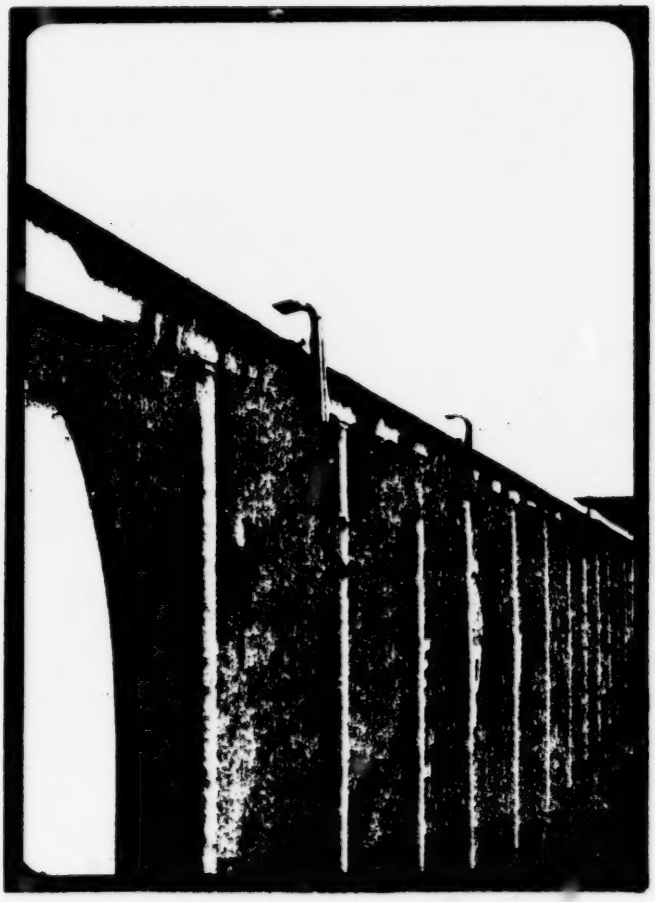


PLATE #7
CLAMP ON CONCENTRATE
CAR COVERS,
VANCOUVER WHARVES

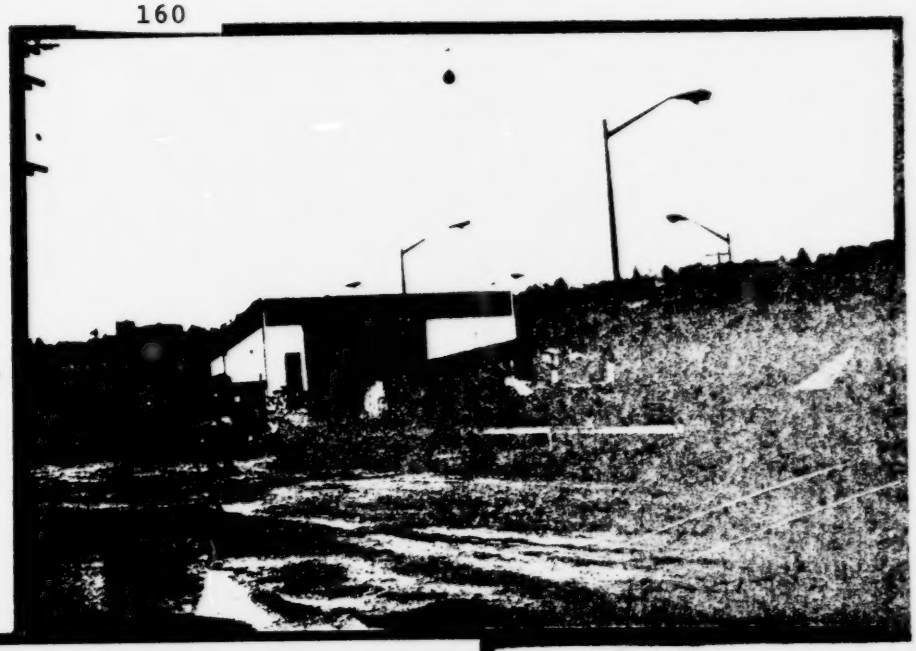


PLATE # 8
COAL CAR ENTERING
ROTARY DUMPER BUILDING
AT NEPTUNE BULK TERMINALS,
NORTH VANCOUVER

PLATE #9
COAL CAR ENTERING
ROTARY DUMPER BUILDING
AT NEPTUNE BULK
TERMINALS,
NORTH VANCOUVER

PLATE #10
EMPTY COAL CARS
LEAVING THE ROTARY
DUMPER BUILDING AT
WESTSHORE TERMINAL,
DELTA, B.C.